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AUTHOR Coole, Walter A.
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ABSTRACT

This publication contains a course outline, syllabus, and self-study units finished and partly tested in the Open Classroom, an auto-tutorial learning laboratory at Skagit Valley College (Washington). This self-contained course in elementary formal logic is designed for use in conjunction with Kalish and Montague's "Logic--Techniques of Formal Reasoning" (1964). Upon completion of this course, the student is expected to: (1) translate between ordinary literal English and formulations of symbolic logic, using Kalish-Montague notation; (2) construct valid derivations in the sentential and first-order predicate calculi; (3) lay a foundation for subsequent studies in mathematics as a systematic study of the properties of numbers; (4) learn how to study logic and mathematics independently. Although there are no formal prerequisites, it is recommended that the student complete a course in informal logic, read with considerable skill, and be able to interpret terse, non-redundant, literal English. The basic course is divided into four units, with a fifth optional unit available to students who wish to work for an "A" grade. All testing is done as the student proceeds from one unit to the next. For each unit of study, the student must perform one translation from English to logic and one derivation selected from the text. The basic course is expected to require about 165 hours. (NHM)

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ED112973

PHILOSOPHIC HEURISTIC INSTRUCTION (PHI) -- III

Course outline
Course syllabus
Polecat Logic Bailout Kit, Numero Uno
Polecat Logic Derivation Sheet

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SUMMARY. This publication contains finished and partly-tested materials for a rigorous course in elementary formal logic.

These materials will be corrected and extended through higher calculi in the Greenbook Abstract & Catalog, *an occasional paper published through ERIC.*

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I with to acknowledge the contributions of the following:

Star McDaniel Heimsath	*Don Mathers*
John McClure	*David Narsico*

and many students who, over the years, have contributed to this model.

Special mention should be made of the contribution of Ken Trueman, a student at The Evergreen State College, whose proof-reading job has caught so many typographic and substantive boobs.

Suggestions and criticism would be welcome; I'd be happy to correspond over technical questions with users.

Walter A. Coole
Open Classroom
Skagit Valley College
Mt. Vernon, WA 98273

COMMENTS.

All materials in this collection can be reproduced satisfactorily on thermofax-ditto or electronic mimeograph stencils, EXCEPT the *Polecat Logic Derivation Sheet*. This format should be reproduced in fairly high resolution technique to bring out the faint tic-marks in the body of the argument. These tic-marks provide the student a visual means of organizing through systematic indentations and provide easy guides for free-hand sketching of boxes required by the Kalish-Montague system. Three images of the Derivation Sheet have been provided.

The syllabus and the Bailout Kit have been proof-read three times; undoubtedly, errors still exist.

JC 750 524

In a polemic published in *Improving College and University Teaching* (Winter 1959), I set forth some reasons for promoting the study of logic. Subsequent experience has shown that the curriculum recommended requires considerably more learning time than is usually available in conventional course increments. This course, then, must be considered as part of a larger corpus of training in critical thinking.

In discussing my choice of texts with colleagues, I frequently encounter the opinion that the Kalish-Montague text is "too difficult for junior college students." In a conventionally-presented course, I would agree. KM is uncompromisingly rigorous and its language is difficult--not because of its vocabulary, but because of its exercise of the rich syntactic repertoire of the English language.

An ancillary objective of this course is to train students to read and use constructively, logical and mathematical texts of high rigor. My own open classroom experience convinces me that it is possible for a well-oriented student of average intelligence to master this text--and to considerable advantage. I therefore believe that KM is the text of choice, and that it will continue to be so for a good many years.

During my years of advanced study at UCLA, I had occasion to discuss the text with Professor Kalish and believe that I have a good intuitive feel for the authors' pedagogical strategies. I can remember Dr. Kalish remarking that no "answer book" would ever be provided for the text. He and Dr. Montague felt that such a publication would be a crutch for a substandard teacher using (or misusing) their text.

It would appear that I should produce an apology for this affront to their intentions...

It is certainly the case that no teacher should undertake to teach formal logic who is unable to write plausible translations and produce elegant derivations with a minimum of hesitation; a competent logic teacher must be so thoroughly in mastery of the sentential and predicate calculi as to be able to write proofs while relating the activity to systemic considerations and thinking of pedagogic problems simultaneously.

The text was written expressly for conventional instruction with lecture and demonstration as the primary mode of interaction with the teacher. Class meetings, then, are to provide much of the detailed "feedback" on student performance.

The presently contemplated course was developed for "open classroom" presentation, where there are no efficient groupings of students. Students are entering the course and completing it individually. The absence of a device such as *Polecat Logic Bailout Kit Numero Uno* would leave the teacher producing elementary proofs repeatedly for single students--not the best use of teacher-time.

For many students, mastery of the predicate calculus will be sufficient to serve them well. However, the course outlined herein treats only the first four chapters of this excellent text (a fifth is treated in the appendix devoted to "A-projects").

In subsequent presentations, through the *Greenbook Abstract & Catalog*, I shall present teaching materials for the remaining chapters of the textbook, as well as some other extentions of the logical system.

It may be questioned why, in a two-year college, such offerings are undertaken. Certainly, the traditional "transfer" student or the "vocational" student is unlikely to have the time, in his brief tenure in a community college, to pursue advanced logical studies.

I believe that advanced philosophical subject matter--including logic--will be increasingly in demand by the older student who will appear in night courses for personal reasons. In Most two-year college philosophy programs, the local development of such courses would be impractical. Perhaps by providing the materials for such independent-study courses through ERIC, I can help my colleagues, at least by providing starting-points for more appropriate community activities.

ELEMENTARY FORMAL LOGIC. Course outline by
Walter A. Coole, Skagit Valley College

Skagit Valley College course number: Philosophy 120

Quarter credits: 5 Semester credits: 3

Average student completion time: 165

Primary goals: upon completion of this course, the student is expected to...

--translate between ordinary literal English and formulations of symbolic logic, using Kalish-Montague notation

--construct valid derivations in the sentential and first-order predicate calculii

--lay a foundation for subsequent studies in mathematics as a systematic study of the properties of numbers

Secondary goal: to learn how to study logic and mathematics independently.

Performance objectives: There are four units in the basic course; their objectives are as follows:

I. to be able to...

--translate complicated English sentences involving: "if ..then" and "it is not the case that..." and their stylistic variants into logical formulations of the minimal calculus;

--construct valid derivations in the minimal calculus;

II. --translate complicated English sentences involving: "or","and","just in case"

--construct abbreviated derivations in the sentential calculus

III. --translate English sentences about "some" and "all"

--construct derivations in the calculus of variables

IV. --translate English sentences involving proper names (and mathematical statements also)

--construct derivations in the full predicate calculus of the first order

The foregoing performances entitle the student to a grade of "B"; to recieve a grade of "A", the student must undertake one of the following options:

--study an optional unit of instruction devoted to enrichment of the basic subject-matter

--equal or beat the instructor in three out of four handicapped competitions involving the unit tests

--act as a group leader for several students taking the course in concert

--coach fellow students through the course

Entry

Persons advising students about this course should be aware that formal logic courses have a reputation for being some of the most difficult-to-master subject matter in any college curriculum.

Oddly enough, there are no curricular prerequisites for the course.

It is recommended that the average student complete informal logic as a preliminary to this course (see course outline).

In general, the student must read with considerable skill, and be able to interpret terse, non-redundant literal English.

Previous success and preference for proofs in high school plane geometry are useful but not essential.

The student should expect to work hard in this course and have a high degree of tolerance for frustration with his temporary lapses in performance. A good sense of humor is a great asset in the study of logic.

This course is not recommended as a substitute for mathematics; it is also contraindicated as therapy for severe emotional problems.

Student materials

Kalish & Montague: *Logic--Techniques of Formal Reasoning.* N. Y.
Harcourt, Brace & World. 1964.
Coole: *Syllabus for Elementary Logic.*
Polecat Logic Derivation Sheets
Notebook, several sharp #2 lead pencils, eraser

Teacher preparation

The prospective teacher should complete this course, including the optional unit on enrichment, before attempting to teach it. He should be able to construct elegant derivations with ease and speed.

Other materials required

Polecat Logic Bailout Kit #1 Model derivations.

Polecat Logic Bailout Kit #3 On MC inference rules.

Cassette player

SYLLABUS FOR ELEMENTARY FORMAL LOGIC by Walter A. Coole, Skagit Valley College*

Your *primary goals* in this course will be to be able to:

- translate between ordinary literal English and formulations of symbolic logic
- construct derivations in the sentential calculus
- lay a foundation for subsequent studies in mathematics as a systematic study of the properties of numbers

and your *secondary goal* will be to learn how to study logic and mathematics independently.

In the process of attaining these goals, you qill pass from the level of ordinary humanity to the exquisite status of LOGICIAN!

This course of study is at least as comprehensive as any other such course in North America--and its standards are high. You'll find that it requires about 165 hours of your time to complete; perhaps even more.

One reason we have set high standards for this course is to insure that transferring students who wish to continue their logical studies will have no trouble, regardless of what school they transfer to. Follow-up studies on students who completed the experimental version of this course indicate that every student started intermediate or advanced courses at the head of the class *despite the fact that in the six institutions studied, logic was reputed to be the most formidable course offered.*

The formal logic you are about to begin studying was developed during the 19th century by Wilhelm Frege and furthur developed by Bertrand Russell and A. N. Whitehead around 1915. Its immediate application was to solving philosophical problems about the reliability of mathematics. It turns out, however, that formal (symbolic) logic serves many other purposes.

The representation of situations in the formal language of logic leads to thinking about problems from a totally and highly constructive viewpoint. By representing events and ideas in the language of formal logic, we can draw some inferences more easily and confidently than if we are operating in the natural language. Remember: the natural languages are more adapted to oral rendition; the language of formal logic was deliberately created to focalize on inference relationships.

*This syllabus accompanies Kalish & Montague: *Logic--Techniques of Formal Reasoning*. Harcourt, Brace & World. 1964. I wish to acknowledge the advice and assistance of: Peter Cleland, John D. Connell, John McClure, David Narsico, and John Reid. I am especially grateful for the counsel of M. Nicklai Bourbaki.

Formal logic, then, allows the problem-solver to make inferences which accomplish two things: (i) he can deduce unerringly from beliefs known to be true and (ii) he can make plausible deductions from questionable beliefs as a means of checking the latter against reality.

In this course, we shall *attempt* to influence your attitude. When the course is completed, your instructor hopes that you'll have acquired enough of a taste for the subject to undertake intermediate and advanced logical studies. Your grade, however, will NOT be based on your feelings toward the subject matter.

Because of formal logic's close relationship to automatic data processing, and the widespread use of computers, you'll find that logic has applications in almost every vocation that uses large amounts of data and decision-making: law, engineering, medicine, education, political science--you name it!

At the present time, the language of symbolic logic is used by relatively few people of highly sophisticated tastes. A few years ago, when I first began to study the subject, symbolic logic was exclusively for for graduate students. Now, you'll find that some symbolic logic is studied in progressive elementary schools!

While not every problem can be solved by formal logic alone, many philosophers feel that this constructed, artifical language is useful in reaching agreements through dialogues.

About prerequisites

No formal prerequisites are demanded for this course. We recommend that you enter the course...

being able to read literal English with good comprehension

understanding how to follow detailed instructions

able to study systematically and skillfully

Course materials

This syllabus

Kalish & Montague: *Logic--Techniques of Formal Reasoning*

Polecat Logic Derivation Sheets

Several sharp #2 lead pencils (don't attempt to do your work in ink)

Eraser

Grading

To attain a grade of "B" you must complete the first four units of this course.

To attain a grade of "A" you must, in addition, accomplish one of the following:

a. Complete Unit V.
b. Compete successfully with the instructor in a handicapped elegance contest.
c. Lead a study-group in logic, consisting of four other students.
d. Act as a logic coach for one hour per day for a 10-week period.

(Other projects may be negotiated with the instructor.)

If you have attained the grade of "B" but not completed an "A" project by the end of the term, your "B" will be reported and subsequently changed if, during the next term, the project is completed.

(More about the "A" projects in Appendix I.)

Testing

There is no final examination for this course. All testing is done as you procede from one unit to the next. For each unit of study, you are required to perform one translation from English to logic and one derivation selected from the text. All unit tests must be done in the vicinity of the instructor's office.

There is no time limit; your textbook may be used as a reference during testing.

Translations must be submitted on notebook paper; derivations on *Polecat Logic Derivation Sheets*. Your work should be done in pencil and should be neat and ledgible; erasures are acceptable.

Translations must demonstrate mastery of the step-wise method explained in the text, but may omit some steps. Derivations must meet minimal standards of validity defined in the text.

Upon completing the test, your instructor will examine results and discuss them with you personally. If you did not pass the test, you will be able to retake it *after you have re-studied the unit thoroughly*.

You may take unit tests during your scheduled conferences or by appointment with the instructor. Casual dropping-in will not ordinarily be honored for testing.

Study groups

As noted above, some students will be working for a grade of "A" by leading study groups. Look for their advertising on the bulletin board if you should want to join one.

If you decide to become a member of a study group, you should not wait until the group gets organized before beginning the work of the course.

Your progress through the course

This course consists of four units which are furthur analyzed into 20 lessons. You should attempt to complete Lesson 1 before your first scheduled conference.

Complete this column. For starred (*) entries, see the unit schedule given you by the instructor; you may choose your own completion dates for intervening steps. Allow for about 8 1/2 hours for each lesson's study.

Unit	*Lesson*	*Plan to complete*	*Date actually completed*	*Lesson reading score %*	UNIT QUIZ RESULTS *Translation*	*Derivation*
I	1					
	2					
	3					
	4	*			P F	I V S E
II	5					
	6					
	7					
	8	*			P F	I V S E
III	9					
	10					
	11					
	12					
	13	*			P F	I V S E
IV	14					
	15					
	16					
	17					
	18					
	19					
	20	*			P F	I V S E

Fill these columns out as you complete each lesson

Fill these columns out circle your score as you pass each unit test

UNIT I

Lesson 1

Your OBJECTIVES for this lesson: (to be attained before attempting the next)

( ) to be able to form the negation of a sentence
( ) to be able to translate an English conditional sentence into partially symbolic formulation and to distinguish antecedent from consequent
( ) to know what sentence letters stand for
( ) to know some Greek letters are and what they will be used for
( ) to be able to explain what subscripts are for
( ) to be able to drop parentheses without goofing
( ) to be able to distinguish what KM* call sentences
( ) to know where to find a list of stylistic variants for "if...then..." and to be able to distinguish which is antecedent and consequent in each

---

*In this syllabus, I'll use the abbreviation "KM" to designate the text and its authors, Donald Kalish and Richard Montague.

This lesson's ASSIGNMENT: (how to reach the objectives)

Read:

In KM* you'll quickly encounter a few Greek letters. You shouldn't be awed by them; every Greek schoolboy masters them in the first grade. KM use the Greek letters to represent sentences and certain "well-formed formulae"--sentences which are combined into *composites* according to the rules.

You should be able to recognize and pronounce these few Greek letters. They are, in order used in the text...

Letter	Pronounciation
Φ	phī
Ψ	psī
X	kī
α	alfa
β	beta
ε	epsilon
ζ	zeta
δ	delta
η	eta

---

*If you've already forgotten what this abbreviates, you're not reading carefully. Start the syllabus from the beginning!

[Page 5.1 follows.]

Since the sentence letters and Greek letters used in KM are restricted, we might run into a problem unless we head it off at the pass. We wish to be able to compute logical relations involving any number of sentences.

By using subscripts thus...

$$\Phi_1 \qquad Q_3$$

we can create symbols of abbreviation for any number of sentences and formulas we want. The two examples given above are pronounced...

phī-sub-one and Q-sub-three

respectively.

Read:

Many students complain that KM is too hard to read. Such complaints are symptoms of inadequate reading and/or failure to master a previous objective. They are not likely to elicit sympathy from the instructor, but he'll be happy to oblige you be recommending ways that you can remedy the problem for yourself--in the most efficient manner.

When you undertake to study a lesson, you should do the following things:

1. establish clearly in your mind what you're trying to accomplish by reading the lesson's objectives carefully
2. work your way through the assignment as advised in the syllabus
3. complete all written work as directed
4. review the assignment by checking off each objective you've met

and re-studying each objective you're not absolutely sure about

If you run into difficulty, here are some ways you can bail yourself out...

1. Write down what page you encountered the problem on

2. Write out briefly what you see the problem to be

3. Try to find a passage in the text or syllabus that deals with the problem

4. Check the classroom for a listing of logic coaches; consult with one of them

5. Ask the instructor

6. If all else fails, try studying

Read:

In reading the text, you'll be asked to answer some questions as you procede. I've abbreviated these exercises by omitting the usual annotations. Each item will call for some kind of response; there are three categories:

i. True-false. These are indicated by simple sentences with no choice indicated.

ii. Conventional multiple-choice. Mark the appropriate response.

iii. Citation alternatives (these are the tricky items). These are indicated by three decimal numbers, immediately after the item. The direct answer to the question appears in the textbook. The decimal numbers indicate three possible places where the answer might appear; *but not necessarily--the answer may be somewhere else!*

The decimal number 45.1 referrs to page 45--the first *quarter* of the page--the passage will begin.

To respond to the citation question, give the alternative (whether offered or not) and write the first few words of the appropriate sentence, thus...

22.4--The quick brown fox...

This may appear a bit opaque now, but a couple of examples will be given shortly.

ACHTUNG! In measuring your text, include the margins.

Several students have discovered that marking the edge of the text in quarters with a felt-tip pen saves a lot of nuisance.

Read pp. 3-12 of KM *carefully* and respond to the following "reading questions" *as you read*. Write your answers on notebook paper.

WARNING! *DON'T EVER* think of or read "→" as equals or and. *ALWAYS* render it as "if...then..." or "...implies..." The penalty for violation of this warning is instant death!

Reading questions:

1. Logic is concerned with arguments, good and bad. *This is a "true-false" item; it happens to be true, according to KM. Therefore, write TRUE or simply T.*

2. Virtue among arguments is known as: A. validity; B. compositness; C. clarity; D. none of these. *This is a conventional multiple-choice question whose correct answer is "A"--that's according to KM. All you have to do is write down the letter "A".*

3. How do we analyze validity? 3.2, 3.4, 4.2 *This is one of those sneaky citation questions. The correct response goes like this...*

> *4.2--We shall analyze validity in steps...*

4. What is the abbreviation for the phrase "...it is not the case that..."? 4.1, 4.2, 4.3 *OK, baby, you're on your own for this one.*

5. What is the abbreviation for the phrase "...if...then..."? 4.1, 4.2, 4.4 *This is another sneaky citation item. This one is doubly sneaky, because the answer in KM doesn't occur in any of the locations suggested. The correct answer is...*

> *4.3--For the phrase 'if..., then' let us use the symbol '→'...*

Note: we may not always agree on the quarter of the page in close measurements. It's nothing to worry about. What is important is selecting a sentence that directly and correctly answers the question.

For the rest of the reading exercises, you're on your own.

---

6. In examining the composite sentence $R \rightarrow T$, A. The antecedent is P and the consequent is Q; B. The antecedent is Q and the consequent is P; C. The antecedent is R and the consequent is T; D. The antecedent is T and the consequent is R; E. Both A and C are correct.
7. When sentences have the same base letter but different subscripts, they are necessarily related.
8. Which of these are part of the KM language? A. English declarative sentences; B. The symbols $\sim$ and $\rightarrow$; C. Sentence letters; D. All of these; E. None of these
9. The appearance of Greek letters at page 6.3 is something to get hysterical about.
10. Capital Greek letters stand for: A. English sentences; B. Sentence letters; C. Composite sentences of the KM language; D. All of these; E. None of these
11. How would you find out what the class of sentences consists of? 6.1, *6.2, 7.1*

12. In the sentence $\sim(P \rightarrow Q)$, the most prominent logical symbol is '$\sim$'.
13. In the sentence $\sim(P \rightarrow Q)$, the most prominent logical symbol is '$\rightarrow$'.
14. Parentheses may be dropped willy-nilly.
15. The sentence in exercise 3, page 8, is a non-symbolic sentence.
16. The sentence in exericise 4 is a symbolic sentence.
17. It is a sentence of some kind.
18. The sentence in exercise 5 is a symbolic sentence.
19. Number 6 is a sentence.
20. What is an abbreviation? 8.3, 8.4, 9.1
21. How do you translate a symbolic sentence into literal English on the basis of a given scheme of abbreviation? 9.1, 9.2, 9.3
22. Give two stylistic variants of "it is not the case that..." 10.4, 11.1, 11.2 (Where does the sentence start?)
23. A concise list of stylistic variants for "if.... then" appears at: 11.1, 11.2, 11.4
24. Concise, italicized directions for translating from English to KM is to be found on: 12.1, 12.2, 12.3

Now check your answers...

1. True
2. A
3. 4.2--We shall analyze validity in steps...
4. 4.2--Let us adopt for the symbol '$\sim$'...
5. 4.3--For the phrase 'if..., then'...
6. C
7. False
8. D
9. False
10. D
11. 6.2--To be more explicit...
12. True
13. False
14. False
15. True
16. False
17. True
18. True
19. False
20. 8.4--More explicitly, let us...
21. 9.2--The process of a literal...
22. 10.4--Two stylistic variants...
23. 11.3--If Φ, then Ψ
24. 12.1--(I) Introduce 'it is not the case that...'

If you scored 90% correct: check out answers you've missed and procede.
If you scored less than 90% correct: complete the reading from the beginning.

Exercises:

Complete the exercises on pp. 12-13. The next time you have a chance, check them out against the model answers in *Polecat Logic Bailout Kit Numero 1.**

Re-read KM, p. 6.2, the characterization of the class of sentences. Then complete the following decision flowchart (p. 10).

Note that a lozenge shape indicates a question; a circle is a conclusion. Indeterminate results are shown in dotted rectangles.

A *composite* sentence is one composed of one or more sentence letters and at least one symbol. Thus, P, Q, and Z are not composite, while...

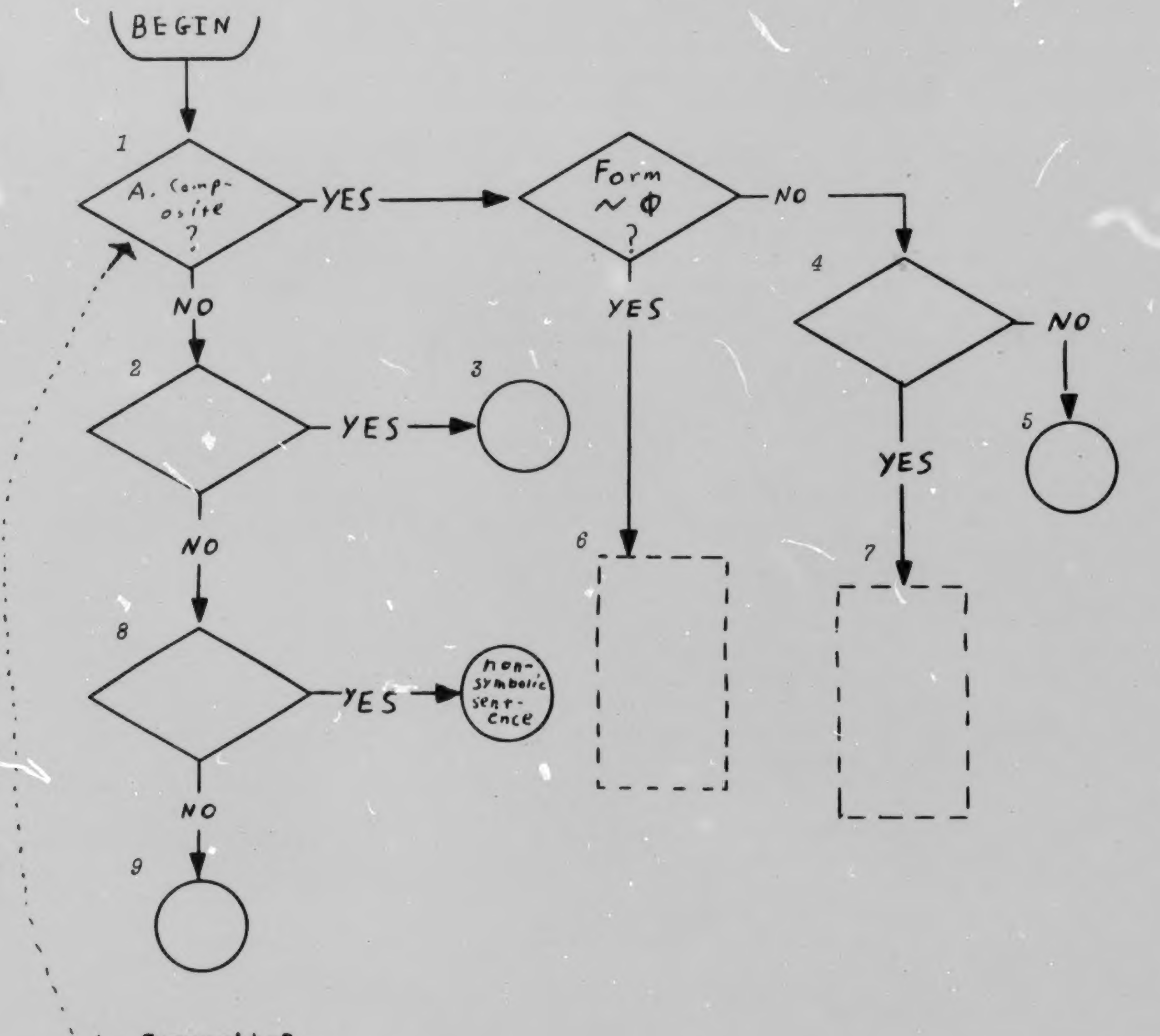
$P \rightarrow Q$

$\sim R$

$(P \rightarrow S) \rightarrow T$ are composites.

---

*Copies are available in the classroom and in the library.


BEGIN
1
A. Composite ?
YES
Form ~ Φ ?
NO
YES
4
NO
2
YES
3
YES
5
NO
6
7
8
YES
non-symbolic sentence
NO
9

A. Composite?
B. Symbolic sentence.
C. English sentence?
D. The status of the composite is the same as the status of either ϕ or ψ .
E. Not a sentence.
F. Sentence letter?
G. The status of the composite is the same as the status of ϕ .
H. Form: $\phi \rightarrow \psi$?

------------*Do not peek below this line before you've fininshed!*--------

1. A
2. F
3. B
4. H
5. E
6. G
7. D
8. C
9. E

REVIEWING this lesson.

Now, return to page 4. Read each objective that was established for this lesson. Make a check mark in each blank beside an objective you feel sure you have met thus: (✓). Re-read appropriate portions of the text or syllabus to cover any objective you're unsure about.

If you make sure that you've met all lesson objectives as you go, you'll avoid time-consuming effort later. Don't attempt to procede to the next lesson until this one is learned thoroughly.

RECORD-KEEPING for this lesson.

Turn back to page 4. In the appropriate columns, write down the date you completed Lesson 1 and your reading score.

COMMENTARY ON TESTING

We're now in a position to tell you what the rules for half the quiz requirements are.

You will be asked to translate from one or more English sentences of the textbook exercises into MC language; ie. the language of KM, Chapter I, involving sentence letters, '~', and '→'.

This translation should be submitted on a separate sheet (notebook paper) from your derivation. It must be written ledgibly and neatly. While only the logical formulation is required, you may write any intermediate steps you wish to show.

If the instructor finds the translation plausible, you have met the requirement. If not, you may take that part of the test over, or you may challenge.

To challenge your instructor's evaluation, it will be sufficient for you to produce a statement that the translation is correct, signed by a person who (all of these):

i. agrees to arbitrate the contention and provide a reference in case he decides in favor of the student

ii. has taken at least three courses in logic from an accredited institution with a grade of not less than "B"

iii. has taught a course in formal logic, set theory, or foundations of mathematics within the last five years in an accredited institution of higher learning in the United States or Canada.

Should the arbitration be decided in favor of the student, the instructor will read, carefully, the reference provided in an attempt to improve his proficiency.

Lesson 2

Your OBJECTIVES for this lesson will be to be able to:

( ) write the first line of a derivation, even though you haven't the foggiest idea how to procede from there

( ) write from memory in symbolic form and apply the four MC inference rules

( ) recognize correct applications of the four MC inference rules and know when they've been misapplied

( ) locate a description of three basic derivation patterns of MC and how to apply them in constructing derivations and completing arguments and sub-arguments

( ) recognize when a derivation has been correctly completed

( ) locate in a hurry and apply a list of five heuristic rules useful in constructing derivations in MC

ASSIGNMENT

Read: KM, pp. 13-28. Respond to the following...

Reading questions:

1. What are the parts of an argument? 13.2, 13.3, 13.4
2. When is a symbolic argument valid? 13.4, 14.1, 14.2
3. The conclusion of a valid argument is always true.
4. How does one establish the validity of a symbolic argument? 14.1, 14.3, 14.4
5. What is the first thing that one writes when constructing a derivation? A. The premises; B. A "Show-line"; C. Both of these; D. Neither
6. It is absolutely necessary to have the whole derivation completely, clearly, and distinctly in mind before beginning a derivation.
7. Which of the following is not an inference rule? A. MP; B. MT; C. DN; D. R, E. All of these are inference rules
8. A list of inference rules in symbolic form, with Greek letters, printed in italics, is to be found at: 15.1, 15.2, 15.3, 15.4
9. Inference rules are mandatory directives.
10. Inference rules may be applied whenever one wants to, provided there are statements of exactly the form of those in the premise-models above the line.
11. The symbols used in stating inference rules indicate the most prominent symbols in the statements exemplifying the application of said inference rules.
12. The abbreviation for modus ponens is MP.
13. The abbreviation for modus tolens is MT.
14. The abbreviation for double negation is DN.
15. The abbreviation for repetition is R.
16. It is necessary to memorize these rules.
17. It is necessary to understand how to apply these inference rules.
18. One can accomplish great things in logic even without understanding the four basic inference rules.
19. There are examples of applications of the four basic rules of inference on: 16.1, 16.2, 16.3, 16.4
20. There is a difference between a derivation procedure and an inference rule.
21. Which of the following is not a derivation procedure of KM, Ch. I? A. Direct; B. Conditional; C. Indirect; D. Universal; E. All of these are described in Ch. I
22. The first explanation of what a direct derivation is occurs in: 16.1, 16.2, 16.4

23. The first explanation of what a conditional derivation is occurs in: 16.1, 16.3, 16.4
24. In effect, a conditional derivation shows that one thing, ϕ, implies another, ψ; it does not show that either ϕ or ψ are true.
25. The truth of (24) explains why it is OK to assume ϕ.
26. The first explanation of what an indirect derivation is occurs in: 17.1, 17.2, 17.3
27. The derivation called indirect derivation is also known as *reductio ad absurdum*.
28. A subsidiary derivation is also known as a *lemma*. (Hint: it ain't in KM.)
29. No valid derivation can have more than one "show" line.
30. A formally-stated, italicized statement of what *can* be done appears at 20.2, 21.1, 21.2
31. When can a "show" line be entered into a derivation? 20.1, 20.2, 20.3
32. What is the annotation required when a premise is entered as a line of a derivation? A. 'Assumption'; B. 'Annotation'; C. 'Assertion'; D. Any of these; E. None of these
33. If 'show $\phi \rightarrow \psi$' is a line of a derivation, which of these can be written as the next line? A. Ø; B. ψ; C. $\rightarrow$; D. None of these; E. Any of these
34. The result of the application of inference rules to antecedent lines can be entered as a line of a derivation.
35. The term "antecedent line" in a context such as #34 includes lines with an uncancelled "show."
36. The term "antecedent line" in a context such as #34 includes lines inside boxes.
37. It is sinful to appeal to an uncancelled show-line.
38. It is sinful to appeal to a boxed line.
39. A formal, italicized statement of the satisfaction of a derivation appears at: 21.1, 21.2, 21.3
40. The italicized statement of derivation rules (20.3-21.3) includes a statement that conditional derivations *must* include an appeal to the antecedent of the conditional to be derived.
41. Regardless of the kind of derivation that has been started, if the line to be derived has been derived, the derivation has done been did.
42. Regardless of what kind of derivation has been started, if a contradiction has been shown, then the derivation has done been did.
43. When a derivation has been completed, one has an option as to whether to box-and-cancel or not.
44. When a derivation has been completed, the logician should smile.
45. There is nothing important between pages 21 and 25.
46. When is an English argument said to be valid? 24.3, 24.4, 25.1
47. Are annotations, strictly speaking, part of a derivation? 25.1, 25.2, 25.4

Now, check your answers...

1. 13.4--An argument, as we shall..
2. 24.3--A symbolic argument is said...
3. False
4. 14.2--To establish the validity...
5. B or D: "conclusion"
6. False
7. E
8. 15.2--The inference rules...
9. False
10. True
11. True
12. True

13. True
14. True
15. True
16. True
17. True
18. False
19. 16.2--For example, in the...
20. True
21. D
22. 16.3--(i) By direct derivation...
23. 16.4--(ii) By conditional derivation...
24. True
25. True
26. 17.2--(iii) By indirect derivation
27. True
28. True
29. False
30. 20.3--The following is an explicit...
31. 20.3--(1) If Φ is any...
32. E
33. A
34. T
35. False
36. False
37. True
38. True
39. 21.2--(6) When the following...
40. False
41. True
42. True
43. False
44. True
45. False
46. 25.2--An English argument is said to be valid...
47. 25.3--Annotations do not...

If you scored 90% correct: check out answers you've missed and procede.
If you scored less than 90% correct: complete the reading from the beginning.

AT THE EARLIEST OPPORTUNITY--Complete *Polecat Logic Bailout Kit Numero 3**.

A Programmed Sequence on Constructing Derivations

David P. Narsico

Directions to the student:

(a) You should procede through this program by reading each frame.
(b) Each frame has a definite response. Write your answer in the space provided or on scratch paper.
(c) As you procede, cover the answer to the frame you're working on; check your answer only after you have written your response.
(d) You should have KM open to pp. 20-21 for reference. We'll refer to the portions of the text in *italics* by the designated numbers--"Steps", although they aren't, in the strictest sense, steps.

---

*Available in the College Library only. Time: about 1½ hours.

[Page 14.1 follows]

---

1. To establish the validity of a symbolic argument with the sentence Φ as its conclusion, we construct a DERIVATION of Φ from the premises of the argument.

One determines the validity of a symbolic argument by constructing

a ______________________________.

DERIVATION

2. An explicit set of directions for constructing a ________________ from given symbolic premises are useful to establish the validity of an argument from given premises.

DERIVATION

3. There are THREE kinds of derivations:
   1. DIRECT derivations
   2. CONDITIONAL derivations
   3. INDIRECT derivations

These _________ kinds of derivations are based upon the form of the symbolic sentence you wish to derive and the form of derivation used.

The derivations you will be learning to construct will be:

1)________________, 2)________________, 3)________________ derivations.

THREE
1) direct, 2) conditional,
3) indirect

4. In order to properly construct these three kinds of derivations from given symbolic premises, an explicit set of directions have been presented in KM, pp. 20-21. The directions and applications of these will be presented in the following frames.
(No response required.)

---

5. Read Step 1 of the directions: (p. 20.3)

Suppose P is the symbolic sentence. Then _________ ______ may occur as a line. The annotation following this line would be

________________. Thus, the whole line would be

1. __________ ___   ____________________

SHOW P
ASSERTION
1. Show P   Assertion

6. Read Step 2:

Suppose that a given premise is P → Q. This premise may then occur as a line. It may be written as:

______________   ________________

Suppose that a given premise is P → (Q → R). It may appear as the line:

______________   ________________

P → Q   Premise
P → (Q → R)   Premise

7. Read Step 3.
(Note: within this course, we *require* the abbreviation "ACD" for "Assumption for Conditional Derivation." The reason for this should become obvious as you procede.)

Example:

1. Show $(\Phi \rightarrow \Psi)$ Assertion
2. Φ ACD

Therefore, if P, R are symbolic sentences such that Show $(P \rightarrow R)$

occurs a line, then _______ may occur as the next line. These two lines, complete with annotation would be:

1. Show (_______ → Assertion

2. __________ ______

---

1. Show $(P \rightarrow R)$ Assertion
2. P ACD

Note: A symbolic sentence of the form $\Phi \rightarrow \Psi$ is called a conditional. It therfore seems appropriate to call a derivation of this nature a conditional derivation with the assumption in the second line called "assumption for conditional derivation.

8. If line 1 in a conditional derivation is...

1. Show $(S \rightarrow T)$ Assertion

the next line would be:

2. ___________ _________________

---

2. S ACD

9. In the following argument:

$P \rightarrow Q. \quad Q \rightarrow R \therefore \; P \rightarrow R,$

remember that the premises are the given symbolic sentences, and the conclusion is that symbolic sentence following the '$\therefore$', which stands for the term 'therefore' (or something to that effect).

In the argument above, the premises are:

__________________ and ________________ and the conclusion

is $\therefore$ __________________.

$P \rightarrow Q$ and $Q \rightarrow R$ and the conclusion is:

$\therefore$ $P \rightarrow R$

10. The conclusion of the argument is what you want to derive. This desired conclusion is indicated immediately in the first line of the derivation. The conclusion you wish to derive follows the term 'show' in the first line.

From the symbolic argument

$P \rightarrow Q. \quad Q \rightarrow R \quad \therefore P \rightarrow R$

the first line of the derivation would be:

1. ___________ (__________) _____________________

---

1. Show $(P \rightarrow R)$ Assertion

11. In the following argument,

$P \rightarrow Q. \quad Q \rightarrow R \quad \therefore P \rightarrow R$

the conclusion, $P \rightarrow R$, is of the form $\Phi \rightarrow \Psi$, which is called a conditional.The conclusion is that part of the given symbolic argument which usually determines the kind of derivation to be constructed.

If the conclusion is a conditional, you would probably begin to construct a conditional derivation.

For which of the following arguments would you probably begin a conditional derivation?

A. $P \rightarrow Q. \quad Q \rightarrow R \quad \therefore P \rightarrow R$
B. $Q \rightarrow \sim R. \quad \sim P \rightarrow R \quad \therefore \sim P \rightarrow \sim Q$
C. $\sim S \rightarrow T. \quad S \rightarrow T \quad \therefore T$
D. $P \rightarrow (Q \rightarrow R). \quad P \rightarrow (R \rightarrow S) \quad \therefore P \rightarrow (Q \rightarrow S)$

A, B, and D.

12. Given the symbolic argument...

$P \to Q$. $Q \to R$ $\therefore$ $P \to R$

you would begin a ____________ derivation and the first two lines would be:

1. ____________ (________) ______________

2. ____________ ______________

CONDITIONAL

1.	Show$(P \to R)$	Assertion
2.	P	ACD

13. Remember that premises may appear as lines followed by the annotation "Premise".

From the following argument, begin a conditional derivation. The premises may be entered as lines 3 and 4.

$S \to T$. $T \to U$ $\therefore$ $S \to U$

1. __________ ( ) __________

2. _____ ____________

3. ____________ ____________

4. ____________ ____________

1.	Show $(S \to U)$	Assertion
2.	S	ACD
3.	$S \to T$	Premise
4.	$T \to U$	Premise

14. Given the symbolic argument:

$P \to (Q \to R)$. $P \to (R \to S)$ $\therefore$ $P \to (Q \to S)$

you would construct a ________________ derivation. The derivation would begin with these four lines:

1. ____

2. ____

3. ____

4. ____

CONDITIONAL

1.	Show $P \rightarrow (Q \rightarrow S)$	Assertion
2.	P	ACD
3.	$P \rightarrow (Q \rightarrow S)$	Premise
4.	$P \rightarrow (R \rightarrow S)$	Premise

15. $S \rightarrow T$. $S \rightarrow T$ $\therefore T$

The conclusion of the above symbolic argument is NOT a conditional. (Remember: a conditional has the form $\Phi \rightarrow \Psi$.)

Therefore a conditional derivation is NOT used to derive this argument's conclusion.

An INDIRECT derivation is generally used.

The conclusion of the symbolic argument above is ____.

To determine the validity of the above symbolic argument you would construct an ______________ derivation.

T
INDIRECT

16. Step 4 is used to begin INDIRECT derivations; read Step 4. (Note: in this course, we will *require* that such lines be annotated by the abbreviation "AID"--for "Assumption for Indirect Derivation".)

This step is used to begin construction of _____________ derivations.

Suppose that P is a symbolic sentence such that 'Show P' occurs as a line. Then ______ may occur as the next line, followed by the annotation "AID".

The first two lines of the indirect derivation would then be:

1. _________ P _______________

2. ______

INDIRECT
~P
INDIRECT
AID

1. Show P — Assertion
2. ~P — AID

17. Remember the second part of Step 4.

Suppose that P is a symbolic sentence such that 'Show ~P' occurs as a line. Then _____ may occur as the next line.

The first two lines of this ____________ derivation would be:

1. _______ ______ ____________
2. _______ ____________

P
INDIRECT

1. Show ~P — Assertion
2. P — AID

18. If P is a symbolic sentence and one wanted to begin an INDIRECT derivation, the derivation would begin in one of two ways:

1. Show P ____________
2. ________ ____________

or

1. Show _________ ____________
2. _______ ____________

---

1. Show P — Assertion
2. ~P — AID

or

1. Show ~P — Assertion
2. P — AID

IF YOU'RE IN THE MOOD FOR A BREAK, THIS IS A GOOD PLACE TO TAKE ONE-- BUT DON'T STAY AWAY FOR MORE THAN 15 MINUTES, OR YOU'LL HAVE TO REVIEW BEFORE GOING ON!

19. So far, two kinds of derivations have been discussed: (i) conditional derivations and (ii) indirect derivations. In the following examples of symbolic arguments, indicate which kind of derivation would be most appropriate:

A.	$(P\to Q)\to Q.\quad Q\to P\quad \therefore\ P$	INDIRECT
B.	$P\to(Q\to R).\quad P\to(R\to S)\quad \therefore\ P\to(Q\to S)$	CONDITIONAL
C.	$\sim P\to Q.\quad P\to Q\quad \therefore\ Q$	______________
D.	$Q\to\sim R.\quad \sim P\to R\quad \therefore\ \sim P\to\sim Q$	______________
E.	$\sim(R\to Q).\quad Q\quad \therefore\ P$	______________
F.	$P\to Q.\quad P\to\sim Q\quad \therefore\ \sim P$	______________
G.	$\therefore\ [(P\to Q)\to P]\to P$	______________

Write the first four lines of the derivation of Example A.

1. ________ _____ ____________________
2. _____ ____________________
3. ___________ ____________________
4. _______ ____________________

A. INDIRECT
B. CONDITIONAL
C. INDIRECT
D. CONDITIONAL
E. INDIRECT
F. INDIRECT
G. CONDITIONAL

1.	Show P	Assertion
2.	$\sim P$	AID
3.	$(P\to Q)\to Q$	Premise
4.	$Q\to P$	Premise

20. Write the first four lines of the derivation of the following symbolic argument:

$P\to(Q\to R).\quad P\to(R\to S)\quad \therefore\ P\to(Q\to S)$

1. _______ _________ ______________
2. ________ ______________
3. ____________ ______________
4. ____________ ______________

1.	Show $P\to(Q\to S)$	Assertion
2.	P	ACD
3.	$P\to(Q\to R)$	Premise
4.	$P\to(R\to S)$	Premise

21. Read step 5, p. 21.2.

Your response to the first reading of Step 5 should be: OH HEL__!

OH HELP!
or OH HELL!

Either response is justifiable.

Note: The following frames should to explain Step 5.

22. Let's look at the first part of Step 5 again.

Suppose you have the antecedent lines:

2. P
3. $P \to Q$

By applying Modus Ponens (MP) [KM, p. 15], to these two lines you have...

4. ______

4. Q

23. Read the end of Step 5 again.

Therefore, if Lines 2 and 3, with annotations are:

2. P (Assumption)
3. $P \to Q$ Premise

then Line 4 should be:

4. Q ___, ___, MP

4. Q 2, 3, MP

24. Lines 2-4 COULD look like this:

2. P (Assumption)
3. $P \to Q$ Premise
4. ____ ___, ___, _____

4. Q 2, 3, MP

If the inference referred to in Frame 24 is unclear (or any of the others, for that matter) you should review *Polecat Logic Bailout Kit Numero 3.*

25. When Step 5 refers to antecedent lines, it refers to a preceding line which is neither boxed nor contains an uncancelled 'Show'.

[The term 'Show' with a line through it, thus:

~~SHOW~~

is called a CANCELLED SHOW.]

The following two lines:

$$\boxed{\begin{array}{l} P \\ P \to Q \end{array}}$$

are contained within a _______.

The line 'Show Φ' contains an UN _______________ SHOW.

The line '~~Show Φ~~' contains a _____________ SHOW.

BOX
UNCANCELLED SHOW
CANCELLED SHOW

26. $\boxed{\begin{array}{l} P \\ P \rightarrow Q \end{array}}$

The lines within a box, as shown above, for example, may NOT be used to infer subsequent lines.

In the following examples...

A.
$$\begin{array}{rll} \begin{array}{r} 2. \\ 3. \end{array} & \boxed{\begin{array}{l} P \\ P \rightarrow Q \end{array}} & \begin{array}{l} \text{Assumption} \\ \text{Premise} \end{array} \\ 4. & Q & 2,\ 3,\ \text{MP} \end{array}$$

B.
$$\begin{array}{rll} 2. & P & \text{Assumption} \\ 3. & P \rightarrow Q & \text{Premise} \\ 4. & Q & 2,\ 3,\ \text{MP} \end{array}$$

which example demonstrates the proper use of antecedent lines to infer Q in Line 4?

Example ___

EXAMPLE B

27. Look at the last part of Step 5.

$$\begin{array}{rl} 1. & \text{Show } P \\ 2. & \sim P \\ 3. & \sim(R \rightarrow Q) \\ 4. & Q \\ 5. & \cancel{\text{Show}}\ R \rightarrow Q \\ \begin{array}{r} 6. \\ 7. \end{array} & \boxed{\begin{array}{l} R \\ Q \end{array}} \end{array}$$

In the example above, which line contains a cancelled 'Show'? _______

Which line contains an UNcancelled 'Show'? _______

Cancelled 'Show': Line 5.
UNcancelled 'Show': Line 1.

THIS IS ANOTHER GOOD SPOT FOR A SHORT BREAK.

28. When 'Show' in Line 1 of a derivation is CANCELLED and all SUBSEQUENT lines are BOXED, the derivation is complete. Which of the following derivations is/are complete?

A.
1. ~~Show~~ $\sim P$
2. $\boxed{P}$
3. $\boxed{P \rightarrow Q}$
4. $\boxed{P \rightarrow \sim Q}$
5. $\boxed{Q}$
6. $\boxed{\sim Q}$

B.
1. Show P
2. $\sim P$
3. $\sim (R \rightarrow Q)$
4. Q
5. ~~Show~~ $R \rightarrow Q$
6. $\boxed{R}$
7. $\boxed{Q}$

C.
1. Show $[(P \rightarrow Q) \rightarrow P] \rightarrow P$
2. $(P \rightarrow Q) \rightarrow P$
3. ~~Show~~ P
4. $\boxed{\sim P}$
5. $\boxed{\sim (P \rightarrow Q)}$
6. $\boxed{\cancel{\text{Show}}\ P \rightarrow Q}$
7. $\boxed{\boxed{P}}$
8. $\boxed{\boxed{\sim P}}$
9. $\boxed{P}$

The completed derivations is/are (circle one or more): A B C

A. Only in derivation A is Line 1 cancelled and ALL subsequent lines boxed.

[However, the other derivations are ready to be completed; all that is necessary is to cancel the 'Show' in Line 1 and box all subsequent lines.]

29. In the following example [KM, p. 25], which lines may NOT be used to infer subsequent lines:

1.	Show $\sim Q$	Assertion
2.	Q	AID
3.	$Q \rightarrow S$	Premise
4.	S	2, 3, MP
5.	$S \rightarrow T$	Premise
6.	~~Show~~ $P \rightarrow T$	Assertion
7.	$\boxed{P}$	ACD
8.	$\boxed{T}$	4, 5, MP

Lines ____, ____, and ____ may NOT be used.

The reasons are that Line ____ contains an UN______________ ________ and

Lines ____ and ____ are __________.

Lines 1, 7, and 8 may NOT be used.
Line 1 contains an UNcancelled 'Show'.
Lines 7 and 8 are boxed.

30. In the following example fill in the missing information...

1.	Show $P \to R$	Assertion
2.	P	ACD
3.	$P \to Q$	Premise
4.	Q	____, ____, ____
5.	$Q \to R$	Premise
6.	____	4, 5, ____

After you fill in the blanks, BOX Lines 2-6 and CANCEL the 'Show' in Line 1.

1.	~~Show~~ $P \to R$	Assertion
2.	P	ACD
3.	$P \to Q$	Premise
4.	Q	2, 3, MP
5.	$Q \to R$	Premise
6.	R	4, 5, MP

NOTE: The derivation is now complete.

31. Read Step 6, p. 21.2-21.4.

An example of (i) is:

1. Show P
2. $\sim P \to Q$
3. $\sim Q$
4. $\sim\sim P$
→5. P

An example of (ii) is:

1. Show $P \to R$
2. P
3. $P \to Q$
4. Q
5. $Q \to R$
→6. R

An example of (iii) is:

1. Show $(\sim Q \to \sim P) \to Q$
2. $\sim Q \to \sim P$
3. Show Q
4. $\sim Q$
→5. P
→6. $\sim P$

In the three examples above, cancel the occurrence of 'Show' and box all subsequent lines.

---

1. ~~Show~~ P
2. ~P → Q
3. ~Q
4. ~~P
5. P

[KM, p. 29]

1. ~~Show~~ P → R
2. P
3. P → Q
4. Q
5. Q → R
6. R

[KM, p. 24]

1. Show (~Q → ~P) → Q
2. ~Q → ~P
3. ~~Show~~ Q
4. ~Q
5. P
6. ~P

[KM, p. 22]

32. Let's take Step 6 apart and examine the first part:
Read Step 6 through clause (i).

EXAMPLE:

	1.	Show P	Assertion
X_1	2.	~P → Q	Premise
:	3.	~Q	Premise
:	4.	~~P	2, 3, MT
X_m	5.	P	4, DN

Since Line 1 is 'Show P' [an instance of 'Show Φ'] you would look for P occurring unboxed among Lines 2-5 in the example.

Does P occur unboxed among Lines 2-5? If so, which line? _______

YES
Line 5

33.

1.	Show $\overset{\downarrow}{P}$	Assertion
2.	~P → Q	Premise
3.	~Q	Premise
4.	~~P	2,3, MT
5.	$\underset{\uparrow}{P}$	4, DN

The above example, demonstrating Step 6(i) is an example of a DIRECT derivation. In this case you set out to 'Show P', and in the last line you did derive ____.

When you derive what you set out to show, the steps in your derivation are finished.

In the example above, cancel 'Show' and box all subsequent lines.

P

1.	~~Show~~ P	Assertion
2.	~P → Q	Premise
3.	~Q	Premise
4.	~~P	2, 3, MT
5.	P	4, DN

34. In a DIRECT derivation, such as this one:

1.	~~Show~~ P	Assertion
2.	$\sim P \rightarrow Q$	Premise
3.	$\sim Q$	Premise
4.	$\sim\sim P$	2, 3, MT
5.	P	4, DN

notice that in the second line you did NOT write an assumption, neither for indirect nor conditional derivation. You began with the premises and subsequently derived P.

This form of derivation is a __________ derivation.

DIRECT

35. Let's look at Part (ii) of Step 6.

Read Step 6, through (ii), but skipping clause (i).

1.	Show $P \rightarrow R$	Assertion
2.	P	ACD
3.	$P \rightarrow Q$	Premise
4.	Q	2, 3, MP
5.	$Q \rightarrow R$	Premise
6.	R	4, 5, MP

Line 1 is of the form 'Show $(\Psi_1 \rightarrow \Psi_2)$'; it appears as 'Show $P \rightarrow R$'.

Therefore, instead of Ψ_2 occurring unboxed among Lines 2-6, you should look for the occurrence of ______. R occurs in Line _____.

The "Show" in Line 1 may be cancelled and all subsequent lines may be boxed.

In the above example, cancel 'Show' and box all subsequent lines.

R

Line 6

1.	~~Show~~ $P \rightarrow R$	Assertion
2.	P	ACD
3.	$P \rightarrow Q$	Premise
4.	Q	2, 3, MP
5.	$Q \rightarrow R$	Premise
6.	R	4, 5, MP

36.

1.	~~Show~~ $P \to R$	Assertion
2.	P	ACD
3.	$P \to Q$	Premise
4.	Q	2, 3, MP
5.	$Q \to R$	Premise
6.	R	4, 5, MP

The above example, demonstrating Step 6(ii), is an example of a conditional derivation.

In this case you set out to 'Show $P \to R$'. In Line 2 you assumed 'P' and in Line 6 you derived ____. Since you have now acquired both P and R (you assumed P and derived R), the steps in your derivation are finished.

The above example shows the completion of a ____________ derivation.

R
Conditional

37. Now, read Step 6, through (iii), skipping (i) and (ii).

EXAMPLE

1.	Show $(\sim Q \to \sim P) \to Q$	Assertion
2.	$\sim Q \to \sim P$	ACD
3.	Show Q	Assertion
4.	$\sim Q$	AID
5.	P	Premise
6.	$\sim P$	2, 4, MP

in the above example, both ___ and its negation, ___, occur unboxed in Lines ___ and ___.

And so, on to more cancelling and boxing.

The first 'Show' to be cancelled is the one in Line ___.

Then, box lines ___, ___, and ___ ,

Do these two things.

P ∼∼P
Lines 5 and 6
3
4, 5, and 6

3.	~~Show~~ Q	Assertion
4.	∼Q	AID
5.	P	Premise
6.	∼P	2, 4, MP

38. Now, read the part of Step 6 that is presented in parentheses.

This statement indicates that '~~Show~~ Φ' may be treated and used in the same manner as 'Φ' is.

Fill in the blanks in the following example:

3.	~~Show~~ Q	Assertion
4.	∼Q	AID
5.	P	Premise
6.	∼P	2, 4, MP
7.	Q → R	Premise
8.	____	___, ___, ____

8.	R	3, 7, MP

39. In the following examp[illegible]

1.	Show (∼Q → ∼P) → Q	Assertion
2.	∼Q → ∼P	ACD
3.	~~Show~~ Q	Assertion
4.	∼Q	AID
5.	P	Premise
6.	∼P	2, 4, MP

In Line 1 you set out to 'Show' the conclusion '(∼Q → ∼P) → Q. You assumed '∼Q → ∼P' in Line 2 asserted Q in Line 3 by a subsidiary indirect derivation. You now have what you set out to show. Therefore, you may now complete the derivation.

Do so in the example above.

1.	~~Show~~ (∼Q → ∼P) → Q	Assertion
2.	∼Q → ∼P	ACD
3.	~~Show~~ Q	Assertion
4.	∼Q	AID
5.	P	Premise
6.	∼P	2, 4, MP

THIS IS THE THIRD GOOD JUNCTURE AT WHICH TO TAKE A BREAK. REMEMBER: IF YOU TAKE MORE THAN 15 MINUTES, YOU SHOULD REVIEW THE WHOLE PROGRAMMED SEQUENCE, BEGINNING AT PAGE 14.

40. Before you go any furthur in constructing derivations, here are some HELPFUL, but NOT INFALLIBLE suggestions intended merely as informal advice. They do NOT have the same status as the official directions for constructing a derivation.

Read the *italicized* passage on p. 26 of KM. Use slips of paper to mark the passages on page 20 and 26--you'll be referring to these frequently during your work on Unit I.

We shall refer to these five heuristic directions as H-1 ... H-5, respectively.

The following is an example of the application of H-5.

3. $\sim(S \rightarrow T)$
4. T
5. Show $S \rightarrow T$

Line 3 is the __________ of a conditional. The NEGATION of a conditional in Line 3 is ______________. Therefore, the conditional you want to show in Line 5 is _____________.

NEGATION
$\sim(S \rightarrow T)$
$S \rightarrow T$

41. In the following example...

1.	Show P	Assertion
2.	$\sim P$	AID
3.	$\sim(R \rightarrow Q)$	Premise
4.	Q	Premise
5.	_____ _ ___	____________

Fill in Line 5.

5.	Show $R \rightarrow Q$	Assertion

42. Another helpful hint: If the consequent of a 'Show' line is a conditional, enter that conditional as a 'Show' line if no other procedure is immediately obvious.

In the following example, '$(Q \rightarrow S)$' is the consequent of the conditional '$P \rightarrow (Q \rightarrow S)$'.

1.	Show $P \rightarrow (Q \rightarrow S)$	Assertion
2.	P	ACD
3.	$P \rightarrow (Q \rightarrow R)$	Premise
4.	$P \rightarrow (R \rightarrow S)$	Premise
5.	$Q \rightarrow R$	2, 3, MP
6.	$R \rightarrow S$	2, 4, MP
7.	__________ _____	________________

7.	Show $Q \rightarrow S$	Assertion

43. Following each example argument below, indicate what kind of derivation you would probably construct and write the first two lines of each.

A. $\sim S \rightarrow T$. $S \rightarrow T$ $\therefore T$ INDIRECT______

1. Show T ______________

2. __________ ______________

B $T \rightarrow (Q \rightarrow R)$. $T \rightarrow (R \rightarrow S)$ $\therefore T \rightarrow (Q \rightarrow S)$ ____________________

1. _________ _____________ ______________

2. _____ ______________

C. $S \rightarrow T$. $S \rightarrow \sim T$ $\therefore \sim S$ ____________________

1. _________ _____ ______________

2. ____ ______________

D. $T \rightarrow \sim U$. $\sim S \rightarrow U$ $\therefore \sim S \rightarrow \sim T$ ____________________

1. _________ ______________ ______________

2. ________ ______________

A. INDIRECT

1.	Show T	Assertion
2.	$\sim T$	AID

B. CONDITIONAL

1.	Show $T \rightarrow (Q \rightarrow S)$	Assertion
2.	T	ACD

C. INDIRECT

1.	Show $\sim S$	Assertion
2.	S	AID

D. CONDITIONAL

1.	Show $\sim S \rightarrow \sim T$	Assertion
2.	$\sim S$	ACD

44. Remembering that the PREMISES may be entered as lines, write the first four lines of the following arguments:

A. $\sim S \rightarrow T$. $S \rightarrow T$ $\therefore T$

1.

2.

3.

4.

B. $T \rightarrow (Q \rightarrow R)$. $T \rightarrow (R \rightarrow S)$ $\therefore$ $T \rightarrow (Q \rightarrow S)$

1.
2.
3.
4.

C. $S \rightarrow T$. $S \rightarrow \sim T$ $\therefore$ $\sim S$

1.
2.
3.
4.

D. $T \rightarrow \sim U$. $\sim S \rightarrow U$ $\therefore$ $S \rightarrow \sim T$

1.
2.
3.
4.

A.	1.	Show T	Assertion
	2.	$\sim T$	AID
	3.	$\sim S \rightarrow T$	Premise
	4.	$S \rightarrow T$	Premise
B.	1.	Show $T \rightarrow (Q \rightarrow S)$	Assertion
	2.	T	ACD
	3.	$T \rightarrow (Q \rightarrow R)$	Premise
	4.	$T \rightarrow (R \rightarrow S)$	Premise
C.	1.	Show $\sim S$	Assertion
	2.	S	AID
	3.	$S \rightarrow T$	Premise
	4.	$S \rightarrow \sim T$	Premise
D.	1.	Show $\sim S \rightarrow \sim T$	Assertion
	2.	$\sim S$	ACD
	3.	$T \rightarrow \sim U$	Premise
	4.	$\sim S \rightarrow U$	Premise

45. Construct a DIRECT derivation for the following argument:

$\sim P \rightarrow Q$. $\sim Q$ $\therefore$ P

1. Show ____ ______________
2. ___________ PREMISE
3. _____ ______________
4. __________ 2, 3, ____________
5. _____ ____, ____

When it's completed, cancel 'Show' and box all subsequent lines.

1.	~~Show~~ P	Assertion
2.	$\sim P \rightarrow Q$	Premise
3.	$\sim Q$	Premise
4.	$\sim\sim P$	2, 3, MT
5.	P	4, DN

Note: in this DIRECT derivation, 'P' in Line 5 is what you started out to Show in Line 1.

46. Construct an INDIRECT derivation for the following argument:

$\sim P \rightarrow Q$. $\sim Q$.'. P

1. _______ ______ ________________
2. ______ ________________
3. ____________ ________________
4. ____________ ________________
5. ____________ ___, ___, ___

1.	~~Show~~ P	Assertion
2.	$\sim P$	AID
3.	$\sim P \rightarrow Q$	Premise
4.	$\sim Q$	Premise
5.	Q	2, 3, MP

Note: in this INDIRECT derivation, '$\sim Q$' in Line 4 is the negation of 'Q' in Line 5. Your assumption '$\sim P$' on Line 2, which led to this contradition, is not true. Therefore 'P' is true.

47. Construct a CONDITIONAL derivation for the following argument:

$P \rightarrow Q$. $Q \rightarrow R$.'. $P \rightarrow R$

1. Show________ ________________
2. ______ ________________
3. ____________ ________________
4. ______ ________________
5. ____________ ________________
6. ______ ________________

When you've completed, cancel 'Show' and box all subsequent lines.

1.	~~Show~~ $P \to R$	Assertion
2.	~~P~~	ACD
3.	$P \to Q$	Premise
4.	Q	2, 3, MP
5.	$Q \to R$	Premise
6.	R	4, 5, MP

NOTE: In this CONDITIONAL derivation, 'R' in Line 6 is the consequent of the conditional '$P \to R$' which you started out to Show in Line 1.

48. Show by constructing a derivation that the following argument is valid: $P \to (Q \to R)$. $P \to (R \to S)$ $\therefore$ $P \to (Q \to S)$

1.

2.

3.

4,

5.

6.

7.

8.

9.

10.

1.	Show $P \to (Q \to S)$	Assertion
2.	~~P~~	ACD
3.	$P \to (Q \to R)$	Premise
4.	$P \to (R \to S)$	Premise
5.	$Q \to R$	2, 3, MP
6.	$R \to S$	2, 4, MP
7.	~~Show~~ $Q \to S$	Assertion
8.	Q	ACD
9.	R	5, 8, MP
10.	S	6, 9, MP

49. Show by constructing a derivation that the following argument is valid:

$\sim P \to Q$. $P \to Q$ $\therefore$ Q

1.

2.

3.

4.

5.

6.

1.	~~Show~~ Q	Assertion
2.	$\sim Q$	AID
3.	$\sim P \rightarrow Q$	Premise
4.	$P \rightarrow Q$	Premise
5.	$\sim\sim P$	2, 3, MT
6.	$\sim P$	2, 4, MT

50. Show by constructing a derivation that the following argument is valid:

$Q \rightarrow \sim R.$ $\sim P \rightarrow R$ $.\because.$ $\sim P \rightarrow \sim Q$

1.

2.

3.

4.

5.

6.

7.

1.	~~Show~~ $\sim P \rightarrow \sim Q$	Assertion
2.	$\sim P$	ACD
3.	$Q \rightarrow \sim R$	Premise
4.	$\sim P \rightarrow R$	Premise
5.	R	2, 4, MP
6.	$\sim\sim R$	5, DN
7.	$\sim Q$	3, 6, MT

51. Show by constructing a derivation that the following statement is valid:

$\sim(R \rightarrow Q).$ Q $.\because.$ P

1.	Show P	Assertion
2.	$\sim P$	AID
3.	$\sim(R \rightarrow Q)$	Premise
4.	Q	Premise
5.	Show $R \rightarrow Q$	Assertion
6.	R	ACD
7.	Q	4, R

52. Show by constructing a derivation that the following argument is valid:

$P \rightarrow Q. \quad P \rightarrow \sim Q \quad \therefore \quad \sim P$

1.

2.

3.

4.

5.

6.

1.	Show $\sim P$	Assertion
2.	P	AID
3.	$P \rightarrow Q$	Premise
4.	$P \rightarrow \sim Q$	Premise
5.	Q	2, 3, MP
6.	$\sim Q$	2, 4, MP

53. Show by constructing a derivation that the following argument is valid:

$\therefore \quad [(P \rightarrow Q) \rightarrow P] \rightarrow P$

1.

2.

3.

4.

5.

6.

7.

8.

9.

1.	~~Show~~ [(P ⟶ Q) ⟶ P] ⟶ P	Assertion
2.	(P ⟶ Q) ⟶ P	ACD
3.	~~Show~~ P	Assertion
4.	~P	AID
5.	~(P ⟶ Q)	2, 4, MT
6.	~~Show~~ P ⟶ Q	Assertion
7.	P	ACD
8.	~P	4, R
9.	P	2, 6, MP

///////// End of Dave's programmed sequence. Nice job, Dave! /////////

ABBREVIATION OF DERIVATIONS

In Chapter II, the text will abbreviate derivations extensively. In this course, there will be several other ways to abbreviate--none of them alter the theory of KM; they just shorten up the writing and make generating derivations a little easier for you. Here are the abbreviation rules...

1. *In place of "Show", write "Sho"--eliminate the 'w'.*
2. *Eliminate the annotation of 'Show' lines, writing nothing. We'll assume that you know by now that all uncancelled 'Show' lines represent baldfaced assertions.*
3. *In annotating linse that result from entering premises, abbreviate the word "premise" as "prem" and indicate by number, which premise is being referred to.*

   Example: 4. P ⟶ Q Prem 2

4. *Annotate assumptions 'ACD' in place of 'Assume for Conditional Derivation; and 'AID' in place of 'Assume for Indirect Derivation'.*

....

COMPLETE THE EXERCISES in KM, p. 26, using *Polecat Logic Derivation Sheets*. At the earlies possible chance, check your results against *Polecat Logic Bailout Kit Numero 1.*

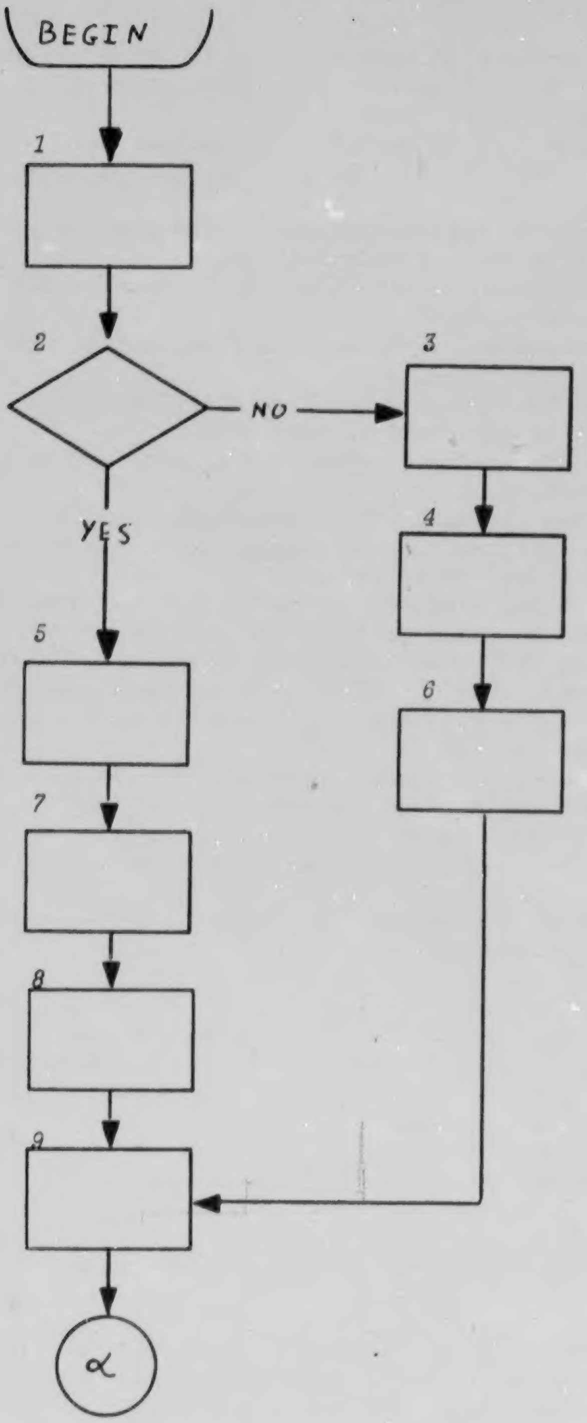
Conceptual exercise:

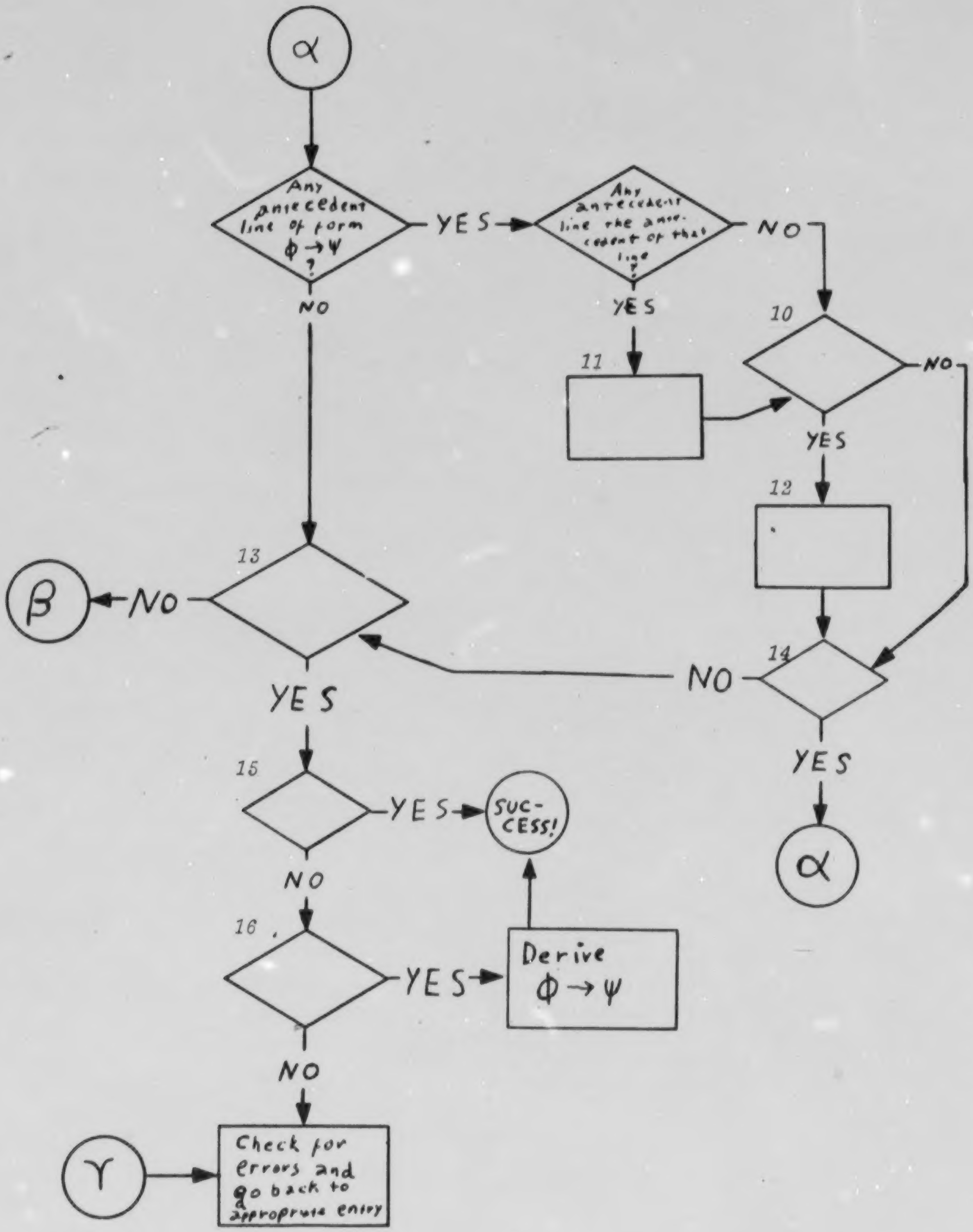
Complete the flowchart on pages 39-41, by filling in the entries offered on page 41.

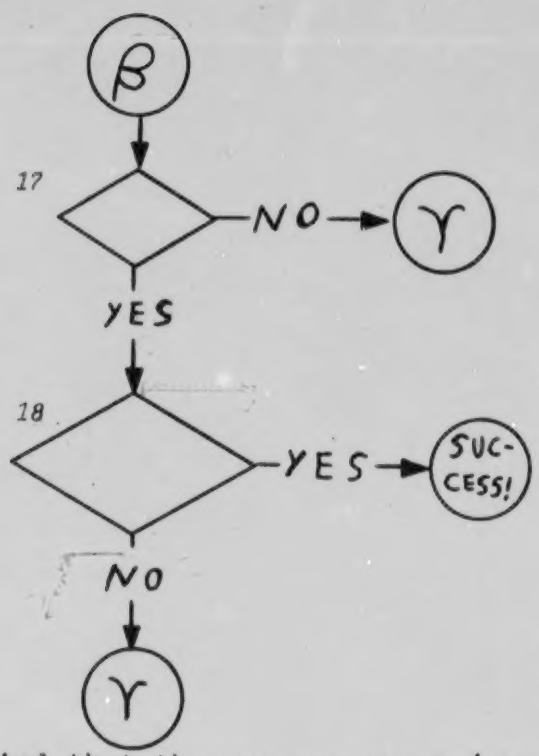
Remember these conventions for the flowchart symbols...

Lozenges: questions and decisions
Rectangles: operations--things to be done
Circles: "transfer points"--to parts of a flowchart on another page or at other places

This exercise is intended to recapitulate the heuristic advice given on p. 26 of KM and the programmed sequence on pp. 14-37 of this syllabus. In your work with the flowchart, you may wish to refer to these two.


BEGIN
NO
YES
α


α
Any antecedent line of form φ → ψ ?
YES
Any antecedent line the antecedent of that line ?
NO
YES
NO
10
11
NO
YES
12
13
β
NO
14
NO
YES
YES
α
15
YES
SUC-CESS!
NO
16
YES
Derive φ → ψ
NO
γ
Check for errors and go back to appropriate entry



A. Keep in mind that the consequent of Ø is to be sought: if desirable, write it as a 'show' line and begin a derivation of it.
B. Enter all premises.
C. Can anything else be done with lines of the form Ø → ψ ?
D. Any antecedent line have the form ~(Ø → ψ) ?
E. Using conditional derivation?
F. Write 'Show Ø'.
G. Enter '~Ø' on the next line of the derivation.
H. Begin a conditional derivation.
J. Any antecedent line the negation of the consequent of that line?
K. Can you get the consequent?
L. Is Ø a conditional?
M. Begin an indirect derivation.
N. Apply MP to those two lines.
P. Keep in mind that a contradiction is the thing to be sought.
Q. Write the antecedent of Ø as an assumption.
R. Apply MT to those two lines.
S. Using indirect derivation?
T Any two lines contradict?

CHECK YOUR ANSWERS...

1. F
2. L
3. M
4. G
5. H
6. P
7. Q
8. A
9. B
10. J
11. N
12. R
13. S
14. C
15. T
16. D
17. E
18. K

COMMENTARY ON TESTING

In Lesson 1, I described in detail, half of each of the four unit tests; that half is concerned with translations.

Having almost completed Lesson 2, you're now in a position to understand in some detail, how the other half of each unit test will be conducted.

After you've completed the translation-test, your instructor will ask you to construct a derivation--one of the arguments treated in KM or a similar argument.

Your derivation will be completed neatly and ledgibly on a *Polecat Logic Derivation Sheet*. The status of your derivation will fall into one of four grades:

> I--invalid: fails to meet minimal validity requirements in KM
> V--valid: barely achieves minimal validity stated in KM
> S--standard: generally follows the heuristic advice given in KM
> E--elegant: demonstrates through logical beauty, ingenuity

If your derivation is invalid, you'll be asked to re-take the test after reviewing the unit.

If your derivation is valid, you may procede to the next unit of study.

If your derivation is standard or elegant, you'll recieve appropriate affection from your instructor.

If you disagree with your instructor's assessment, you have recourse to the arbitration rules set forth in Lesson 1.

REVIEW

Return, briefly to page 12 and check out your attainment of each lesson objective.

ATTITUDE CHECKUP

Let's see how you do on the following few questions...

1. Symbolic logic is difficult...
    A. For everybody
    B. For nobody
    C. For those who stubbornly refuse to read the text carefully

2. There is a vast difference between the rules of validity and the strategy for completing the derivation. (True-false)

3. It is absolutely necessary to have a clear, distinct idea of every step of a derivation before starting to write. (True-false)

4. Exercise #14 on p. 26 is an odd-ball. (True-false)

5. The italicized print on page 26 is algorithmic. (True-false)

If you agree with the answers given below, your attitude is favorable to the furthur study of logic.

1C 2True 3False 4True 5False

RECORD your completion data on page 4.

Lesson 3

This lesson will simply consolidate the knowledge you've gained in the first two lessons of the course. There will be no new objectives and little reading.

Exercises: KM, pp. 29-30, omitting #23.

Do your translations on notebook paper, assigning sentence letters [P, Q, R...Z] in the order of first occurences in the exercise.

Perform the required derivations on *Polecat Logic Derivation Sheets*.

CHECK your work at the earliest opportunity in *Polecat Logic Bailout Kit Numero 1.*

BIG HINT! If a derivation becomes hopeless, check out the translation first. You will probably have some difficulty with '...only if...'. Review KM, p. 11.

RECORD your lesson-completion as you did before.

Lesson 4

Your OBJECTIVES for this lesson:

Upon completing Lesson 4, you should be able to...

( ) distinguish between proofs and other kinds of derivations
( ) prove any theorem of the MC by KM rules

This lesson's ASSIGNMENT:

Read: KM, pp. 34-37.

Reading questions:

1. What is a theorem? 34.2, 34.3, 34.4
2. What is a proof? 34.4, 35.1, 35.2
3. The proof of T1 given in the text is valid.
4. Which theorems are known as the principle of the syllogism? 35.1, 35.2, 35.3
5. Which theorems are called the laws of double negation? 35.4, 36.1, 36.3
6. What is Peirce's Law? 37.1, 37.2, 37.3
7. In solving exercises 26 and 27, the student will find the suggestions on page 26 useful.

Now check your answers...

1. 34.4--As we stated earlier...
2. 34.4--a derivation corresponding...
3. True
4. 35.2--T4 and T5...
5. 36.3--T11 and T12...
6. 37.3--T23 is known...
7. True

Complete the exercises on p. 37 of KM on *Polecat Logic Derivation Sheets*; and, at your earliest convenience, check them out in *Polecat Logic Bailout Kit Numero 1.*

Comment: A "standard" derivation is one which is constructed by heavy reliance on the heuristic advice given in KM, p. 26. In many cases, rote application of this advice yields an "elegant" derivation.

Inspect your derivations (proofs to be more specific) and attempt the following two questions:

1. The second line of the standard proof of T4 is:

   A. $P \rightarrow Q$
   B. $Q \rightarrow R$
   C. $P \rightarrow R$

2. The second line of the standard proof of T15 is:

   A. $\sim P \rightarrow Q$
   B. $\sim Q \rightarrow P$
   C. $\sim Q$
   D. P
   E. None of these

ANSWERS...

1. A 2. A

If you don't agree, you may want to discuss the reasons with your instructor before taking the unit test.

Aren't you elated! You're now ready for the UNIT TEST.

Record your results for Lesson 4 and take the test, either at a scheduled conference or by appointment (no casual dropping in!).*

When you've passed the test, record your results for the unit (I) and procede to Unit II and Lesson 5.

At this point, you're one-quarter of the way to course completion with a grade of at least "B".

UNIT II

This unit will lead you to mastering the SC (sentential calculus) in all its glory.

The vocabulary of MC is quite persimonious. It doesn't allow for much expression its syntax. SC has three more syntactic symbols along with many accompanying rules--rules that tell you how to draw inferences when using these symbols. You'll also get syntactic rules and heuristic advice.

Fairly primitive computers have a full battery of SC features.

Lesson 5

Your OBJECTIVES for this lesson will be to be able to ...

( ) locate a characterization of SC sentences
( ) decide whether an expression is an SC sentence according to KM
( ) translate rather difficult sentences from English to SC formulations
( ) locate in a hurry: a list of stylistic variants of 'and', 'or', and 'if and only if'

ASSIGNMENT:

READ: KM, pp. 39-41

Reading questions:

1. How many logical constants are added to the KM language in Chapter II?
   A. One; B. Two; C. Three; D. Four; E. Five
2. The new symbols are: A. Uniary, like '$\sim$'; B. Binary, like '$\rightarrow$'
3. The critters flanking '$\wedge$' are called conjuncts.
4. The critters flanking '$\vee$' are called disjuncts.
5. The critters flanking '$\leftrightarrow$' are called constituents.
6. What passage, written in italics, describes what things fall into the class of sentences? 40.1, 40.2, 40.3
7. Parentheses don't make any difference.

*You may use your text during the unit tests.

8. The phrase "sentences in the official sense" has something to do with parentheses.
9. Exercise #3 on page 41 is: A. A sentence in the official sense; B. A sentence, but only in the unofficial sense; C. Not a sentence
10. Respond to #4 the same way.
11. Respond to #5 the same way.

Check your answers...

1. C
2. B
3. True
4. True
5. True
6. True
7. False
8. True
9. A
10. B
11. A

Exercises: KM, p. 42, #7-10. At your earliest convenience, check your answers against *Polecat Logic Bailout Kit Numero 1.*

Furthur reading: KM, pp. 42-45.

Reading questions:

12. The process of literal translation from the KM language to literal English is described on: 41.4, 42.2, 42.3
13. A list of stylistic variants of 'and' on page 43.2 includes: A. although; B. but; C. both...and; D. who; E. all of these
14. The word 'unless' is translated by '∧'.
15. The phrase 'neither...nor' is discussed on: 43.2, 43.3, 43.4
16. Directions for translating from English to KM are on: 44.1, 44.2, 44.3
17. It is totally unnecessary waste of time to write out all of the steps of the translation process.
18. Students endowed with considerable talent can easily omit the writing of all of the steps of the translation process even when first beginning to do it.
19. The more difficult a computational problem is, the less writing should be done.

Answers...

12. 42.2--The process of...
13. E
14. False
15. 43.4
16. 44.3--To find a symbolization...
17. False
18. False
19. False

Exercises: KM, pp. 45- 47. Write out all steps of the translation. At your earliest convenience, check your answers against the models given in *Polecat Logic Bailout Kit Numero 1.*

COMMENTS: The symbol '∨' is a representation of one of the two meanings of the English 'or'--the inclusive meaning often represented with characteristic barbarism of the legal profession as 'and/or'. On rare occasion, the Scheffer-stroke, '/', is used to represent the "exclusive" sense--'not both, but one'

A little contemplation of the English equivalent of '↔', 'if and only if' may yield some insight into the puzzling 'only if', given as a stylistic variant of 'if--then' in KM, Ch. I.

RECORD your reading question percentages and completion date on p. 4 of this syllabus.

Lesson 6

OBJECTIVES. To be able to ...

( ) locate in a hurry, a list of the added SC inference rules and apply them without error when the opportunity arises

( ) locate in a hurry, a list of six bits of heuristic advice which work almost every time in constructing SC derivations and apply this advice judiciously

ASSIGNMENT.

Read: KM, pp47-57.

Reading questions:

1. One cannot use new logical symbols to any inferential advantage unless new inference rules are introduced to tell how to use them.
2. What is the sentential calculus? 47.1, 47.2, 47.4
3. How many new inference rules are added to the logical repertoire of KM on page 47? A. Two; B. Three; C. Four; D. Five; E. Six
4. These rules can be glossed over lightly as unimportant.
5. The rule of simplification is abbreviated by 'S'.
6. There is only one version of the rule of simplification.
7. The second version of the rule of simplification is, in some editions of KM, misprinted.
8. Simplification permits one to detach conjuncts from a composite statement.
9. There should be two versions of the rule of adjunction.
10. The abbreviation of 'adjunction' is 'ADD'.
11. The rule of adjunction permits one to glue two statements together into a composite statement.
12. The abbreviation of 'addition' is 'ADJ'.
13. The disjunct added to the premise-statement with the rule of ADD must appear in the derivation as an antecedent line.
14. The disjunct added to the premise-statement with the rule of ADD must be true.
15. The disjunct added to the premise-statement with the rule of ADD must not be a composite statement.
16. The abbreviation for modus tollendo ponens is MTP.
17. The application of MTP allows one to get rid of a false disjunct, leaving a simpler, true statement.
18. The abbreviation of 'biconditional-conditional' is 'BC'.
19. Only one version of BC is important, namely, the left-to-right.
20. The rule of BC must be applied before an MP application in some cases; without it, it might be difficult to unpack some composite statements.
21. The abbreviation of 'conditional-biconditional' is CB.
22. It may be important, when dealing with the strategy of derivations, to remember what the rule of CB is.
23. The junk on pp. 48-50 is unimportant, and can be ignored with impunity.

24. What new interpretation of the phrase 'inference rule' crops up in Ch. II? 50.1, 50.2, 50.3

25. Is $P \wedge (Q \wedge R)$ equivalent to $(P \wedge Q) \wedge R$? 50.4, 51.1, 51.3

26. There is no instructive material on pp. 50-55.

27. There is no instructive material on pp. 55-57.

Check your answers...

1. True
2. 47.2--The sentential calculus is...
3. E
4. False
5. True
6. False
7. False
8. True
9. False
10. False
11. True
12. False
13. False
14. False
15. False
16. True
17. True
18. True
19. False
20. True
21. True
22. True
23. False
24. 50.3--The interpretation, however...
25. 51.1--T25...
26. False
27. False

NOTES. Let us extend, for this course at least, our abbreviatory options for proofs and derivations--acceptable on quizzes and worthy of widespread practice.

When the *first* 'sho' line has as its *major* logical connective, '↔', you may abbreviate the second line by simply writing:

2. sho →

This will be interpreted as meaning the conditional corresponding to the bi-conditional in Line 1, where the antecedent is the left-hand constituent and the consequent is the right-hand constituent.

When the 'sho' of Line 2 is cancelled, and extant, subsequent lines are boxed, the next line written ("Line #") may be rendered:

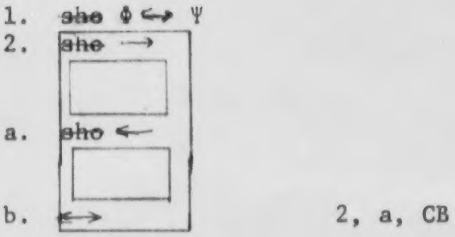
#. sho ←

with obvious interpretation. When that line is shown, the final line of the derivation will be abbreviated:

##. ↔

and will be interpreted as representing the original bi-conditional--exactly as written in Line 1.

Thus, a derivation:



is acceptable.

But DO NOT attempt to apply this abbreviation scheme more than once in a derivation, lest the hail of arrows suggest Custer's perception of the Battle of Big Horn!

*AND ANOTHER THING...*When appealing to a theorem, sentence-letter *replacements must be shown.*

Read carefully, the six bits of heuristic advice given on p. 55.

Exercises: KM, p. 55: #22-23. As soon as you can, check your proofs against *Polecat Logic Bailout Kit Numero 1.*

Review questions:

28. The last line of the standard proof of T28 is justified by which of these rules? A. CB; B. BC; C. MP; D. MTP; E. ADD
29. Which of these is the fourth line of the standard proof of T29? A. P; B. Q; C. Q ∧ R; D. either Q or Q ∧ R; E. none of these
30. The rule of simplification appears in the standard proof of T34.
31. The major logical feature of the last line of the standard proof of T38 is '→'.
32. The fifth line of the standard proof of T44 is: A. P; B. Q; C. P ∧ Q; D. either Q or P ∧ Q; E. none of these

Check your answers...

28. A 29. E 30. True 31. False 32. B

RECORD your completion date and reading percentages on p. 4 of this syllabus.

Lesson 7

OBJECTIVES: to be able to...

( ) locate the abbreviatory clauses for constructing abbreviated derivations and recognize correct and incorrect applications of them

( ) apply these clauses with moderate skill in shortening derivations

( ) reconstruct unabbreviated derivations from abbreviated ones

( ) recall in your own words, the derived rules of SC and CD and apply them correctly to shorten derivations

( ) construct proofs of any SC theorem within a reasonable time, considering the availability of abbreviatory clauses and the complexity of the theorem

( ) apply regularly, six bits of *perfectly dandy* heuristic advice which works darn near every time in constructing abbreviated SC derivations

ASSIGNMENT: KM, pp. 57-61.

Reading questions:

1. In addition to clauses (1) - (6) on pp. 21-22, along with the reinterpretation on page 50, two new clauses will be added which allow for abbreviating derivations.
2. The abbreviations mentioned in (1) above must be applied whenever the opportunity arises.
3. One must be able to see the application of clauses (7) and (8) in order to follow someone else's proof.
4. Clauses (7) and (8) can save considerable time, and hence make the discovery of derivations easier.
5. The logical structure of the expression being replaced in a theorem by application of rule (7) -- that is, the expression above the line in the diagrammatic indication is: A. Always more complex than the replacing expression; B. Never more complex than the replacing expression; C. Always a single sentence letter; D. Invariably without a logical constant; E. Both B and D
6. One can use different expressions to replace the same letter in the same application of clause (7).
7. A "collapsed sequence" justified by (8) can include assumptions.
8. The annotation of a collapsed sequence should tell the reader of a derivation exactly what unabbreviated-derivation lines are being omitted.
9. A student who cannot regenerate unabbreviated-derivation lines from the annotation of a collapsed-sequence line is missing something.
10. A student who discovers himself puzzled by a large number of collapsed-sequence instances should attempt to find out what he lacking and correct the situation.
11. The correct annotation of #7, p. 61.3, line 2, should be: A. Assumption (for conditional derivation); B. Assumption (for indirect derivation); C. Assumption (for direct derivation); D. None of these
12. For line 3, A. 2, MT; B. Premise, 2, MT; C. Premise, 2, MP; D. None of these.
13. For line 4, A. 3, MT; B. Premise, 3, MP; C. Premise, 3, MT; D. None of these

14. For line 5, A. 4, MT; B. Premise, 4, MT; C. Premise, 4, MP; D. None of these
15. As instructed in #26, p. 62.1, construct the derivation of (6). Use clauses (1) - (7). The shortest derivation possible has how many steps? A. 9; B. 10; C. 11; D. 13; E. 14

Check your answers...

1. True
2. False
3. True
4. True
5. E
6. False
7. False
8. True
9. True
10. True
11. B
12. D
13. D
14. D
15. B

Exercises: KM, p. 62, #27-28. DON'T PEEK BELOW THE DOTTED LINE BEFORE YOU DO THEM!

....

#27

1. ~~Sho~~ R
2. $\boxed{R}$ T18, Prem 2, MP, Prem 1, MP

#28

1. ~~Sho~~ R
2. $\boxed{R}$ T2, Prem 2, MP, Prem 1, MP

READ: KM, pp. 62-68

16. Are many of the remaining derivations of Chapter II considerably simplified by the addition of clauses (7) and (8)? 62.1, 62.2, 62.3
17. What is the derived rule of separation of cases? 64.1, 64.2, 64.3
18. How many patterns of separation of cases are there? A. One; B. Two; C. Three; D. Four; E. More than five
19. Separation of cases allows for considerable ease in inventing some derivations.
20. What is the derived rule of conditional-disjunction? 64.4, 65.1, 65.4
21. Application of the derived rule of conditional-disjunction allows for considerable ease in inventing some derivations.
22. The rule of SC is mentioned in the italicized strategic advice (69.3).
23. The rule of CD is mentioned in the italicized strategic advice (69.3).
24. A complete list of sentential calculus theorems appears at: 80.1, 80.2, 80.3
25. The first implication sign appears in T1.
26. The first negation sign appears in T11.
27. The first conjunct appears in T24.
28. The first disjunct appears in T46.
29. The "subject matter" of T1-T10 is implication.
30. The "subject matter" of T11-T22 is negation.
31. The "subject matter" of T24-T32 is conjunction.
32. T42 tells about the relation of disjunction to implication.
33. T45 tells about the relation of conjunction to implication.
34. The "subject matter" of T74-T100 is the biconditional.
35. The heuristic advice, 69.3-71.4, is useless, and should not be read before undertaking the exercises.

ANSWERS:

16. 62.2--Many of the remaining.
17. 64.3--We shall refer..
18. C
19. True
20. 65.2--Another useful pattern...
21. True
22. True
23. True
24. 80.3--9. Appendix list
25. True
26. True
27. True
28. False
29. True
30. True
31. True
32. False
33. False
34. True
35. False

Exercises: KM, pp. 68-69. You might care to read the six bits of heuristic advice on pp. 69-70 before you waste half a day beating your head out on this batch!

At your earliest convenience, check your answers against the model proofs in *Polecat Logic Bailout Kit Numero 1.*

Read: KM, pp. 69-71.

Review questions:

36. It is easier to follow an abbreviated derivation than an unabbreviated one. (Use your instructor's opinion as a guide.)
37. Your instructor has more experience with reading derivations than you have.
38. It is easier, always, to invent an unabbreviated derivation than an abbreviated one.
39. At least one theorem in the exercises required the application of SC for its derivation.
40. At least one theorem in the exercises required the application of CD for its derivation.

ANSWERS: 36. True 37. True 38. False 39. False 40. False

Lesson 8

There are no formal objectives for this lesson; it simply consolidates your learning for Unit II.

ASSIGNMENT: Complete the exercises in KM, pp. 71-72, #36-39. Use notebook paper for the translations; when assigning the sentence letters P, Q,...Z to sentences, assign in order of their first application in the English statements. (Hint: check page 43 for translating phraseology.) Write out all steps of the translation process.

Write your derivations on *Polecat Logic Derivation Sheets.*

At your earliest convenience, check your efforts against the models in *Polecat Logic Bailout Kit Numero 1.*

WHEN YOU COMPLETE THE TEST FOR UNIT II, YOU'L BE HALFWAY THROUGH THE COURSE. YOU SHOULD BE READY FOR THAT TEST NOW.

And have you been keeping your records on page 4 of this syllabus?

UNIT III

This unit begins your study of the predicate calculus (PC) as an extention of SC. The text, KM, points out that not all inferences we "know intuitively" can be accomplished formally with the machinery of SC. The authors propose, then, to add some syntactic and inferential rules that allow for more sophisticated logical shenannigans.

The sympolic structures they develop are logical patterns common in law and the sciences--called, sometimes, 'universal generalizations', among other things. Just because these logical patterns are used to govern you and attempt predictions which involve your well-being--you should understand these patterns thoroughly.

When you gring into problematic situations, new information--particularly from written scientific and statutory sources, you will find it convenient to be able to apply the logical rules of *UI*, *EI*, and *EG* correctly. The more skill, the more you will be able to use and to criticize erroneously constructed inferences involving generalizations.

Lesson 9

OBJECTIVES--to be able to...

( ) recognize English names and corresponding KM variables
( ) write quantifying phrases of KM correctly
( ) list from memory the predicate letters
( ) distinguish well-formed formulae from nonsense
( ) locate in a hurry, a recursive characterization of KM first-order PC formulae and decide, on the basis of that characterization, which symbol-strings are formulae and which are not
( ) decide when an occurrence of a variable is free and when it's bound

ASSIGNMENT.

Read: KM, pp. 85-88.

Reading questions:

1. The following argument is valid according to the system of deduction known as the sentential calculus:

   All professors are nutty.
   Don is a professor.
   Don is nutty.

2. The following argument is valid according to the system of deduction known as the sentential calculus:

   If Dick is a professor, then he's nuts.
   Dick is a professor.
   Dick is nuts.

3. The difference between the example in #1 and #2 has something to do with which of the following: A. 'all'; B. 'is'; C. internal structure of the sentences having logical properties; D. the presence of class names; E. A, B, and C, but not D
4. Which of the following are expressed by '⋀'? A. For each....; B. For every....; C. All....; D. A and B; E. A, B, and C
5. Which of the following are expressed by '⋁'? A. There is at least one; B. Some...; C. Any...; D. A and B; E. A,B, and C
6. What is an existential quantifier? 86.1, 86.2, 86.3
7. What is an universal quantifier? 86.1, 86.2, 86.3
8. What is a phrase of quantity? 86.1, 86.2, 86.3
9. A formula of English is a sentence of English or an expression containing occurrences of a variable which becomes a sentence of English when some or all of these occurrences are replaced by English names.
10. Which of the following is not a formula of English? A. Penelope is a flirt; B. my x has fleas; C. those shoes cost x dollars; D. x - y = z; E. All of these are formulas of English
11. Which of the following are predicate letters? A. E; B. G; C. P; D. Q; E. None of these
12. 'x has hair' could be abbreviated by which of the following? A. Ex; B. Fx; C. Gx; D. The second and third of these; E. All of these
13. To what use will the capital letters "A" ... "E" be put? 87.1, 87.2, 87.3
14. What is the vocabulary of the language KM introduces in Ch. IV? 86.4, 87.3, 87.4
15. An italicized, formally stated exhaustive statement of the class of formulas occurs smack-dab in the middle of page 87.
16. Said statement has a bit of recursivity in it.
17. Clause (5) allows 'VxQ' to be a formula.
18. What is a symbolic formula? 87.4, 88.1, 88.2
19. The following is a universal generalization of 'x hits y on the head with z': ⋀x ⋀y ⋀z (x hits y on the head with z)
20. The following is an existential generalization of 'x gibbers': ⋁x (x gibbers)

ANSWERS:

1. False
2. True
3. E
4. E
5. D
6. 86.2--We shall abbreviate...
7. 86.2--We shall abbreviate...
8. 86.2--The English counterparts..
9. A
10. E
11. B
12. D
13. 132.1--In addition to the...*
14. 131.3--Expessions such as...**
15. True
16. True
17. True
18. 88.1--More precisely the class...
19. True
20. True

Exercises: KM, pp. 88-89, #1-10.

---

*A very tricky item!

**Another!

Check you results...

1. (Not fully) symbolic but nevertheless a formula
2. (Fully) symbolic
3. Not a formula
4. Symbolic
5. Symbolic
6. Symbolic
7. Not a formula
8. Not a formula
9. A symbolic formula
10. A formula, but not symbolic

Read: KM, pp. 89-90.

More reading questions:

31. The third occurrence of 'x' in (2), p. 89.3, is free.
32. Which of these affect freedom and bondage? A. quantifying phrases; B. parentheses; C. intervening sentential symbols; D. ledgibility of the print; E. both A and B
33. When is an occurrence of a variable bound? 89.1, 89.2, 89.3
34. When is an occurrence of a variable free? 89.2, 89.3, 89.4
35. When is sentence symbolic? 89.4, 90.1, 90.2

ANSWERS:

31. True
32. E
33. 89.3--In general, an occurrence...
34. 89.4--An occurrence of a variable...
35. 90.2--By a symbolic sentence...

Exercises: p. 90, #11-#13. (Note: do not count the variables in quantifying phrases.)

Review questions: These questions refer to the exercises you have just finished....Indicate your response by the following letter-to-number association: A = 0; B = 1; C = 2; D = 3; E = 4.

36. How many bound occurrences of x are there?
37. How many free occurrences of x are there?
38. How many bound occurrences of y are there?
39. How many free occurrences of y are there?
40. How many bound occurrences of z are there?
41. How many free occurrences of z are there?

ANSWERS:

36. 1 37. 1 38. 0 39. 1 40. 4 41. 0

Lesson 10

OBJECTIVES: to be able to...

( ) translate difficult sentences from English to KM formal symbolism
( ) locate and use a list of stylistic variants for "each x" and "there is an object x, such that..."

ASSIGNMENT.

Read: KM, pp. 91-95.

Reading questions:

1. There is a correspondence between 'For eachx, x is bald' and 'Everything is bald'.
2. There is no correspondence between 'For each x, x is bald' and 'Each thing is bald'.
3. There is a correspondence between 'For each x, x is bald' and 'Anything is bald'.
4. There is a correspondence between 'There is an object x such that x is bald' and 'At least one thing is bald.'
5. The word 'some' has a pretty dependable translation in KM.
6. The word 'any' has a pretty dependable translation in KM.
7. 'Only mammals are rabbits' can be paraphrased as 'For each x (if x is a rabbit, then x is a mammal).
8. 'None but females are cows' can be paraphrased as 'For each x (if x is a cow, then x is female).
9. It is impossible to list all the combinations that are expressible in terms of phrases of quantity.
10. The more difficult a translation task, and the more unsure one is of the correct translation, the less one should write in accomplishing the translation.
11. Directions for translating into English on the basis of a given scheme of abbreviation are to be located at: 93.1, 93.2, 93.3
12. Directions for symbolizing an English formula are to be located at: 94.2, 94.3, 95.1
13. Sometimes, directions for doing something are more complicated to read than the task of the doing.
14. If you fold your hands and look helpless, someome will explain how to do translations so that you won't have to go to the effort of studying the testbook.

ANSWERS...

1. True
2. False
3. True
4. True
5. True
6. False
7. True
8. True
9. True
10. True
11. 93.2--The process of literal translation...
12. 94.3--To find a symbolization...
13. False
14. True

Exercises; KM, pp. 95-98, except #32 and #36. Please write out all steps of the translation process; use notebook paper.

At your earliest convenience, check your translations against the models in *Polecat Logic Bailout Kit Numero 1.*

Review questions:

15. The examples given on pp. 96-98 are of no value; they were put there by the authors to fill up space and run up the price of the book.
16. In order to be able to translate from English to logic, it is necessary for the sentence to be true.
17. In order to be able to translate from English to logic, it is sufficient to be able to understand the syntactic words, e.g., 'all', 'some', 'is'...

ANSWERS:

15. False 16. False 17. True

Lesson 11

OBJECTIVES: to be able to...

( ) recognize and invent proper substitutions on variables

( ) recognize and invent universal and existential instantiations, and existential generalizations

( ) locate, in a hurry, a list of PC inference rules; recognize correct and incorrect applications of them; apply them to antecedent lines correctly and fruitfully

( ) perform universal generalizations in derivations

( ) explain in your own words, KM's restriction on EI, including a good reason why the restriction was made

( ) explain in your own words, KM's restriction on universal derivations, including a good reason why the restriction

( ) construct unabbreviated derivations of moderately complex conclusions in PC

ASSIGNMENT:

Read: KM, pp. 99-105.

Reading questions:

1. What is a proper substitution of a variable? 99.1, 99.2, 99.3
2. Which of these rules establishes the validity of the inference 'Since everybody has to do his homework, Don has to do his homework.' A. Universal instantiation; B. Existential generalization; C. Either of these; D. Neither of these
3. How many new rules of inference are introduced in Ch. III? A. 0; B. 1; C. 2; D. 3; E. Four or more
4. Which of these rules has a restriction? A. Universal instantiation; B. Existential generalization; C. Existential instantiation; D. Universal generalization; E. B and D
5. What is a universal derivation? 100.1, 101.1, 101.2
6. How many universal quantifier signs are indicated in the show-line schema in 101.2? A. 0; B. 1; C. 2; D. 3; E. k
7. What is the monadic quantifier calculus? 101.4, 102.1, 102.2
8. Where are the directions for constructing a derivation in the monadic quantifier calculus? 101.1, 101.2, 101.4

9. Examine the proof of T202, p. 104.2. Can the entries on Line 5 and Line 6 be interchanged? A. Yes B. No

ANSWERS...

1. 99.1--We say that...
2. A
3. D
4. C
5. 101.1--The new form...
6. E
7. 101.4--That part of the...
8. 102.2--(1) If Φ is any...
9. B

Pay attention, now! Pay careful attention to the restrictions (1) on EI (p. 102.3) and (2) universal derivation (p. 103.2).

Exercises: KM, p. 105. Check your answer when convenient.

Lesson 12

OBJECTIVES: to be able to...

( ) apply correctly, three PC abbreviatory clauses to shorten derivations

( ) cite the rule of EI correctly in a "collapsed line"

( ) locate in a hurry, a list of eight bits of heuristic advice which work almost every time in constructing PC derivations and apply this advice faithfully and fruitfully

( ) prove any theorem of KM's first order of PC within a reasonable time, considering the complexity of the theorem to be proven

ASSIGNMENT.

Read: KM, pp. 106-114.

Reading questions:

1. This unit will study the abbreviation of derivations.
2. What is an instance of a sentential theorem? 106.1, 106.2, 106.3
3. Clause (7) -- on 106.3 -- justifies the citing of T201 in annotating a line of an abbreviated derivation.
4. How many versions of the derived rule of QN are there? A. 0; B. 1; C. 2; D. 3; E. 4
5. The following statement is a good mnemonic, if a bit less formal than KM would put it:

   QN allows one to jerk a negation through a
   quantifier phrase; but it turns it upside down.
6. Clause (9) -- page 107.2 -- prohibits the use of EI in a "collapsed-sequence" line.
7. What about the rule of Add and the added disjunct? 107.1, 107.2, 107.4
8. What about the rule of UI and the variable of instantiation? 107.1, 107.2, 107.3
9. What about the rule of EG and the variable of generalization? 107.2, 107.3, 107.4
10. Examine the proof of T229, page 112. Is line 4 in error? A. Yes; B. No

11. The reason for the surprising answer to number 10 can be seen by a careful examination of the text on page(s): A. 102.3; B. 107.3; C. 108.2; D. None of these; E. B and C

12. The informal suggestions (pp. 115.4-117.1) are of no prospective value and should not be read before assaulting the exercises on p. 114.

ANSWERS...

1. True
2. 106.2--By an instance
3. False
4. E
5. True
6. False
7. 107.3--Also, in connection...
8. 107.3--Also, in connection...
9. 107.3--Also, in connection...
10. B
11. E
12. False

Exercises: KM, pp. 114-115, #39-45. Check your answers when convenient.

Lesson 13

There are no formal objectives for Lesson 13; it simply consolidates your learning for Unit III.

ASSIGNMENT: Complete the exercises in KM, pp. 117-118, OMITTING #61. Do translations on notebook paper and derivations on *Polecat Logic Derivation Sheets*.

At your earliest convenience, check your efforts against the models given in *Polecat Logic Bailout Kit Numero 1*.

You're almost three-quarters through the basic course! All that's left is the unit test. Good luck!

UNIT IV

After all of the foregoing, you are still without the logical symbolism for such assertions as:

Don finds the company of adventurous women exciting.

The first few pages of KM, Ch. IV, correct this unfortunate paucity. The reason that Chapter III's language is incapable of such predications is that all of its termsare variables--and you gotta have term-constants in a language to make assertions about specific individuals.

The main thrust of Chapter IV is to develop a logic which can account for specific names of individuals. The superior student will be able to develop his own rationale of the advantages of KM term-constants over the proper names of English.

Lesson 14

OBJECTIVES: to be able to...

( ) recognize terms and names of both English and KM and characterize

'terms' and 'proper names' in your own words
( ) distinguish between a term letter and a predicate letter in your own words
( ) explain the role of superscripts in the KM notational scheme
( ) locate in a hurry, an exhaustive characterization of the terms and formulae of KM, applying these dicta to distinguishing KM sentences from symbolic garbage
( )recognize instances of free and bound variables in official and unofficial notation
( ) convert from official to unofficial notation

ASSIGNMENT.

Read: KM, pp. 131-136.
Reading questions:

1. All names are terms.
2. All terms are names.
3. Some terms have names in them.
4. Some terms have variables in them.
5. How many places can an operation letter have? 132.1, 132.2, 132.3
6. Superscripts will tell how many terms to expect after an operation letter.
7. Superscripts will tell how many terms to expect after a predicate letter.
8. The following is a four-place English predicate: 'x hit y on the head with a z while wearing w'.
9. What are the symbols of the new Chapter IV KM language? 132.4, 133.4, 134.4
10. What is a symbolic term? 134.1, 134.2, 134.3
11. What is a symbolic formula? 134.4, 135.1, 135.2
12. What were the only symbolic terms occurring in the language of Ch. III? 135.1, 135.2, 135.3

ANSWERS...

1. True
2. False
3. True
4. True
5. 132.3--For any nonnegative...
6. True
7. True
8. True
9. 133.4--The extended language...
10. 134.3--The symbolic terms...
11. 135.1--The class of...
12. 135.2--The only symbolic...

Exercises: KM, p. 136.

ANSWERS...

1. D 2. A 3. A 4. B 5. E 6. E 7. E 8. D
9. E 10. D

Read: KM, pp. 136-137.

Reading questions:

13. When is the occurrence of a symbolic term said to be bound? 136.2, 136.3, 136.4
14. When is the occurrence of a symbolic term said to be free? 136.2, 136.3, 136.4
15. What is a symbolic name? 137.1, 137.2, 137.3

ANSWERS...

13. 136.4---An occurrence of a...
14. 136.4---An occurrence of a...
15. 137.2---We can also...

Exercises: KM, p. 137; check your answers at your earliest convenience in *Polecat Logic Bailout Kit Numero 1.*

Read: KM, pp. 137-138.

Exercise: KM, p. 138. Check your answers at the earliest convenience.

Review questions:

16. KM often speak of mathematical notation as "English".
17. Two-place predicates are often used in English to express such relations as "greater than", "stupider than", and "snazzier than".
18. The difference between a term and a formula is cogent.
19. Informal notation will make it easier to read complicated formulae.

ANSWERS...

16. True 17. False 18. True 19. True

Lesson 15

OBJECTIVE: at the completion of this lesson, you should be able to...

( ) follow cogently, difficult translations from English to KM

ASSIGNMENT.

Read: KM, pp. 138-143.
Reading questions:

1. When is α an apparent variable of ϕ ? 138.2, 138.3, 138.4
2. What is an abbreviation? 139.1, 139.2, 139.4
3. What steps constitute the process of literal translation into English? 140.1, 140.2, 140.3
4. How should one proceed in order to find a symbolization of a formula of English? 141.1, 141.2, 141.3
5. It is tempting to attempt a direct, one-step translation from English to KM symbolization.
6. It is tedious to proceed from English to KM symbolization by the route indicated on pp. 141-143.
7. It is stupid to do otherwise.

1. 138.4--If Φ is a... 5. True
2. 139.2--Thus an abbreviation... 6. True
3. 139.3--The process of literal...7. True
4. 140.1--As before, we say...

Exercises: KM, pp. 143-145, #14-15.

ANSWERS...

#14--1. G 2. C 3. D 4. A 5. B

#15--1. h 2. o 3. t 4. p 5. i 6. s
7. d 8. a 9. m 10. g 11. r 12. u
13. k 14. f 15. h 16. b

Exercises: KM, pp. 145-148, #16-33. Check your answers as soon as convenient.

Lesson 16

OBJECTIVES: at the completion, you will master the following skills...

( ) using proper substituion of arbitrary terms in the application of UI and EI
( ) constructing derivations of simple extended PC arguments
( ) translating from English to KM

ASSIGNMENT.

Read: KM, pp. 148-150.

Reading questions:

1. Which of these symbolic expressions can be used to represent the proper name of a person? A. B^o; B. x; C. F; D. all of these; E. none of these
2. In the application of UI, any term may be substituted for the variable of instantiation.
3. In the application of EI, any term not appearing in a preceding line may be substituted for the variable of instantiation.

ANSWERS...

1. A 2. True 3. False

Exercise: KM, p. 150, #37, 38.

ANSWERS...

#37--b, c, f, g, h, i, k. #38--a, c, d, e, g, i

Exercises: KM, pp. 150-151, #39-#47. Check your answers when convenient.

Lesson 17

OBJECTIVES: at the end of this lesson, you should be able to...

( ) follow extended PC theorem proofs of considerable difficulty
( ) prove moderately difficult theorems of the extended PC

ASSIGNMENT.

Read: KM, pp151-155.

Reading questions:

1. Which of these is a monadic formula? A. Fx; B. P; C. F(xy); D. All of these; E. Only the first two
2. The sequence of order in the occurrence of several quantifying phrases makes a difference of meaning: A. Always; B. Sometimes; C. Never
3. Which of these theoretical studies use principles expressed in T255 and T256? A. Russell's paradox; B. Axiomatic set theory; C. Both of these; D. Neither of these
4. When is a symbolic formula said to be without overlay? 153.1, 153.2, 153.3
5. Every monadic formula is equivalent to a monadic formula without overlay.
6. The prenex normal form is named after the great Viennese mathematical logician, August Wilhelm von Prenex.
7. A formula is in prenex normal form just in case it is a symbolic formula consisting of a string of quantifier phrases followed by a formula without quantifiers.
8. Every symbolic formula is equivalent to one in prenex normal form.

ANSWERS:

1. E
2. B
3. C
4. 153.1--A symbolic formula...
5. True
6. False
7. True
8. True

Exercises: KM, p. 155, #48-51. Check your answers as soon as convenient.

Lesson 18

OBJECTIVES: Upon mastering this lesson, you should be able to...

( ) apply the Rule of Alphabetic Variance (AV) correctly to the appropriate formulae
( ) study a rigorous logic textbook systematically

ASSIGNMENT.

Read...

You are near the end of this course in elementary formal logic. I hope that you've not only learned something you can use practically, but have acquired a taste for formal logic as a game. If so, you'll show this by asking your instructor about continuing your studies.

In this course, you have been guided through your reading rather closely, with frequent checks of your mastery.

In future courses, you will be asked to work out your own methods of study; thus, we've given you a model for working in advanced logic, and the prose of mathematics and science.

Here is an outline of the method you've been using, stated in terms of heuristic advice for studying advanced logic and mathematics. Save it for future use.

i. Survey the reading quickly.
ii. Determine what is to be learned.
iii. In many cases, you should also get in mind what applications the content has -- both in subsequent learning and in out-of-school activities.
iv. Read the text thoroughly, noting specific details that seem to be important as well as following the overall pattern of what is being stated.
v. Put the recently-learned material to work immediately, either in the solution of textbook problems or problems of your own invention.
vi. When you have completed the application of your learning, review the main points of the lesson by summarizing what you have learned. If you don't memorize the content of the lesson, it may be helpful to make some kind of record of where specific, frequently-used information can be looked up, in case you must consult the text.

Read KM, pp. 155-157, using the procedure outlined above.

Exercises: KM, pp. 156-157, # 52.

ANSWERS: (a) and (c) do NOT follow correctly. (b) and (d) do.

Lesson 19

OBJECTIVES: to be able to...

( ) apply the Rule of Substitution on Predicate Letters
( ) look forward to completing this course in one more lesson

ASSIGNMENT.

Read: KM, pp. 157-161.

Exercises: KM, pp. 161-164. Check your results.

Lesson 20

OBJECTIVES: to be able to...

( ) abbreviate derivations like mad
( ) applaud for yourself, having completed this course

ASSIGNMENT.

Read: KM, pp164-167.

Exercises: 167-169. Check your results.

YOU ARE NOW READY FOR THE FOURTH AND FINAL CHAPTER TEST.

When you pass it, you will have achieved a grade of "B" for the course. To procede to a grade of A, note the options in Appendix I on the next page.

APPENDIX I: "A" Projects

The foregoing syllabus describes a course of study which entitles you to a grade of "B". To reach a grade of "A", extra work must be done.

You may choose any ONE of the following projects for this extra work. These projects may be undertaken concurrently with your regular work; OR, if your schedule is a bit rough, you may complete the project within a reasonable time after your "B" has been reported, and the instructor will change your grade subsequently.

Also, if you like, one or more of these projects can be used as the basis of a special course for more credit--for details, se the instructor.

OPTION I: Enrichment of the basic course (Unit V)

In the pursuit of this unit of study, you are required to define your own objectives in each lesson. Before beginning each lesson, you should write out your objectives--and if in doubt about the objectives' acceptability, negotiate them with the instructor.

Your objectives can be inferred (not deduced by strict calculation, however!) from surveying the assignment in the text; they should follow the pattern used in the basic part of the course. Note, please, that the verb is *active* and *describes observable performances.*

To demonstrate mastery of each lesson, you should submit all exercises associated with the reading assignments given below--with whatever else you care to offer.

Lesson 2'*

KM, Ch. I, Section 4, pp. 30-34
Section 6, pp. 37-38

(Discuss your conduct of this lesson with the instructor before proceding.)

Lesson 8'

KM, Ch. II, Exercises, Group III, pp. 72-73
Section 6, pp. 73-75
Section 7, pp. 76-78
Section 8, pp. 79-80

Lesson 13'

KM, Ch. III, Section 8, pp. 118-124
Section 9, pp. 124-128
Section 10, p. 128

KM, Ch. IV, Section 10, pp. 170-176
Section 11, pp. 177-178
Section 12. pp. 178-179

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*We'll designate Unit V's lessons by a primed number. If you're doing this project concurrently with the basic course, you'll be able to use this device to coordinate your work.

OPTION II: Competing with the instructor (Handicapped Elegance Contests)

This project is designed for the malicious student who likes to put his teachers down. Oddly enough, in this case, you can raise your grade for doing it.

Of course, I recignize that your instructor, if competent as a logic teacher, should be more practiced in his performance than a beginning student. (If not, he should go back to school!) So, we give the teacher a handicap.

To undertake this project, you must declare your intentions at the very beginning of the course and stay on schedule in your progress through it.

All unit tests must be taken by appointment--*not during scheduled conferences.* When you take your quiz, you will be given a stopwatch. You are asked to time your performance.

Acceptable results must include:

- no erasures
- neat, legible work
- accurate translation, depicting *all* steps of the process as given in KM
- A derivation which is at least "standard" and tends toward "elegance"

Note: No definition can be given for 'elegance'; but but between two derivations, the following rules of thumb shall apply in order of precidence:

1. *The more elegant derivation has fewer steps.*
2. *The more elegant derivation appeals to fewer rules and theorems in justification.*
3. *The more elegant derivation is easier to follow.*
4. *The more elegant derivation is more abundant in* ingenious, sneaky, and soul-satisfying *strategems.*

Your results should be as good or better than your instructor's and should be accomplished in no more than four times the instructor's time; the instructor's performance time includes: time to perform the same test, inerruptions, and daydreaming.

You must beat the instructor three quizzes out of four to meet the requirement for a grade of "A" in this project.

OPTION III: Study Group Leader

To achieve a grade of "A", you will act as a group leader for a group of at least four other students who take the course and meet regularly as a group for mutual self-help.

You recieve your "A" when the four students complete the basic course.

You will be responsible for recruiting the students and arranging meeting times, both with the students and the instructor.

You may use the bulletin board to assist you in recruitment. Your group should meet at least once a week when the instructor can visit.

All member should take each quiz at the same time--normally at group meetings.

OPTION IV: Coaching

To fulfill the requirements for this project, you must be present in the conference room on a schedule which is posted. Either:

--one hour a day for a 10-week period
--five hours a week
--some other arrangement acceptable to the instructor

During this time, you are to assist other students taking the course and, in general, perform coaching duties outlined elsewhere. When you have no customers, you may study on the course

To become a coach, tell your instructor; he'll show you how to get started.

If, at any time, you fall behind schedule, you must begin the project over or choose another.

POLECAT LOGIC BAILOUT KIT Numero 1.

Walter A. Coole, Skagit Valley College

This booklet contains model translations and derivations for assignments in Kalish & Motague: *Logic: Techniques of Formal Reasoning*, Chapters I-IV.

Translations follow the strategies set forth in the text; derivations are "standard" (follow the heuristic advice closely) or "elegant" (apply abbreviatory techniques to produce a short, sometimes-ingeneous, argument.

Derivations are presented on *Polecat Logic Derivation Sheets*. Wherever convenient, several derivations have been presented on a single page to conserve space.

In checking proofs and derivations, the reader should be aware that these are only examples. There are many valid proofs of the same theorem.

UNIT I

Lesson 1. pp. 12-13

#1 $P \rightarrow (Q \rightarrow R)$

(i) $(P \rightarrow (Q \rightarrow R))$

(ii) (logic is difficult → (Alfred will pass → Alfred concentrates)

(iii) (If logic is difficult, then (if Alfred will pass, then Alfred concentrates))

Canonical translation: If logic is difficult, then if Alfred will pass then he concentrates.

Free translation: If Alfred will pass, then he concentrates--that is, assuming logic is difficult.

#2 $S \rightarrow (R \rightarrow [\sim P \rightarrow Q])$

(i) $(S \rightarrow (R \rightarrow [\sim P \rightarrow Q))$

(ii)(The text is readable → (Alfred concentrates → (∼logic is difficult → Alfred will pass)))

(iii) (If the text is readable, then (if Alfred concentrates, then (if it is not the case that logic is difficult, then Alfred will pass)))

Canonical translation: If the text is readable, then if Alfred concentrates, then it is not the case that logic is difficult, then Alfred will pass.

Free translation: Let's assume that the text is readable; then, on condition that Alfred concentrates, if logic isn't difficult, then he will pass.

#3 $(R \rightarrow P) \rightarrow \sim Q$

(i) $((R \rightarrow P) \rightarrow \sim Q)$

(ii) ((Alfred concentrates → logic is difficult) → ∼Alfred will pass)

(iii) ((Alfred concentrates → logic is difficult) → it is not the case that Alfred will pass)

(iv) ((If (if Alfred concentrates, then logic is difficult), then it is not the case that Alfred will pass)

Canonical translation: If if Alfred concentrates, then logic is difficult, then it is not the case that Alfred will pass.

Free translation: Alfred won't pass, given that if he concentrates, logic is difficult

#4 --Solved in textbook.

#5 If logic is difficult, Alfred will pass only if he concentrates.

(1) (If logic is difficult, then (if Alfred will pass, then Alfred concentrates)

(2a) (Logic is difficult → (Alfred will pass → Alfred concentrates)

(2b) (same)

(2c) $(P \rightarrow (Q \rightarrow R)$

(2d) $P \rightarrow (Q \rightarrow R)$

#6 Alfred will pass on condition that if he will pass only if he concentrates then he will pass.

(1) (If (if (if Alfred will pass, then Alfred concentrates), then Alfred will pass) then Alfred will pass)

(2a) (((Alfred will pass → Alfred concentrates) → Alfred will pass) → Alfred will pass)

(2b) (same)

(2c) $(((Q \rightarrow R) \rightarrow Q) \rightarrow Q)$

(2d) $([Q \rightarrow R] \rightarrow Q) \rightarrow Q$

#7 If if if Alfred concentrates, then he will pass, then he will secure employment, then he will marry.

(1) (If (if (if Alfred concentrates, then Alfred will pass), then Alfred will secure employment), then Alfred will marry)

(2a) (((Alfred concentrates → Alfred will pass) → Alfred will secure emplyment) → Alfed will marry)

(2b) (same)

(2c) $(((R \rightarrow Q) \rightarrow T) \rightarrow U)$

(2d) $([R \rightarrow Q] \rightarrow T) \rightarrow U$

#8 It is not the case that if Alfred will secure employment provided that the text is readable, then he will marry only if he concentrates.

(1) (It is not the case that (if (if the text is readable, then Alfred will secure employment), then (if Alfred will marry, then Alfred concentrates)))

(2a) (It is not the case that ((the text is readable → Alfred will secure employment) → (Alfred will marry → Alfred concentrates)))

(2b) (∼((the text is readable → Alfred will secure employment) → (Alfred will marry → Alfred concentrates)))

(2c) $(\sim((S \rightarrow T) \rightarrow (U \rightarrow R)$

(2d) $\sim([S \rightarrow T] \rightarrow [U \rightarrow R])$

#9. Alfred will pass only if he concentrates provided that the text is not readable.

a) ∼S → (Q → R)
b) Q → (∼S   R)

#10. It is not the case that Alfred concentrates if the lectures are dull.

a) ∼(V → R)
b) V → ∼R

#11. Alfred will not secure employment if the fails to concentrate on condition that the lectures are dull.

a) V → (∼R → ∼T)
b) (V → ∼R) → ∼T

Lesson 2. p. 26

#12 Derived in textbook

Ex #13

i v [✓ s] e*

1.	Show' P → (Q → S)		1.
2.	P	ACD	2.
3.	P → (Q → R)	Prem 1	3.
4.	P → (R → S)	~~Prem 2~~	4.
5.	~~Sho~~ Q → S		5.
6.	Q	ACD	6.
7.	~~Sho~~ S		7.
8.	∼S	AID	8.
9.	Q → R	3, 2, MP	9.
10.	R → S	4, 2, MP	10.
11.	∼R	10,8, MT	11.
12.	∼Q	9, 11 MP	12.
13.	Q	6, R	13.

*We contemplate four "grades" for derivations:

*i*nvalid: misapplying the rules of inference (KM, p. 15) or directions for construcing derivations (KM, pp. 20-21)--additional rules will emerge as the course develops

*v*alid: applying rules correctly, but introducing unnecessary, but benign, steps--this degree of correctness is minimally required for the course

*s*tandard: applying the heuristic advice (KM, p. 26)--not absolutely required for the course, but desirable

*e*legant: characterised in the course syllabus, p. 67--expected only of the talented student

For comparison, the student may wish to compare the following derivation of the same argument. It is more elegant than the previous one because...

1. it is shorter
2. it is more direct (fewer 'show' lines and boxes)
3. it is more straightforward (uses *modus ponens* in lieu of *modus tollens*
4. it applies a sneaky strategem: introducing the premises only when needed

Ex #13

i v s [✓ e]

1.	~~Show~~' $P \to (Q \to S)$		1.
2.	P	ACD	2.
3.	~~Sho~~ $Q \to S$		3.
4.	Q	ACD	4.
5.	$P \to (Q \to R)$	Prem 1	5.
6.	$P \to (R \to S)$	Prem 2	6.
7.	$Q \to R$	5, 2, MP	7.
8.	$R \to S$	6, 2, MP	8.
9.	R	7, 4, MP	9.
10.	S	8, 9, MP	10.

Ex #14

i v [✓ s] e

1.	~~Show~~' $([P \to Q] \to P) \to P$		1.
2.	$[P \to Q] \to P$	ACE	2.
3.	~~Sho~~ P		3.
4.	$\sim P$	AID	4.
5.	$\sim [P \to Q]$	2, 4, MP	5.
6.	~~Sho~~ $P \to Q$		6.
7.	P	ACD	7.
8.	~~Sho~~ Q		8.
9.	$\sim Q$	AID	9.
10.	P	7, R	10.
11.	$\sim P$	4, R	11.

Ex #14

i v s [✓ e]

1.	~~Show~~ ([P → Q] → P) → P		1.
2.	[P → Q] → P	ACD	2.
3.	~~Sho~~ P		3.
4.	∼P	AID	4.
5.	∼[P → Q]	2, 4, MT	5.
6.	~~Sho~~ P → Q		6.
7.	P	ACD	7.
8.	∼ P	4, R	8.

Ex #15

i [✓ v] s e

1.	~~Show~~ Q		1.
2.	∼Q	AID	2.
3.	P → Q	Prem 1	3.
4.	∼P → Q	Prem 2	4.
5.	∼P	3, 2, MT	5.
6.	∼∼P	4, 2, MT	6.
7.	P	6, DN	7.

Ex #15

i v s [✓ e]

1.	~~Show~~ Q		1.
2.	∼Q	AID	2.
3.	P → Q	Prem 1	3.
4.	∼P → Q	Prem 2	4.
5.	∼P	3, 2, MT	5.
6.	∼∼P	4, 2, MT	6.

Ex #16

i [✓ v] s e

1.	~~Show~~ ∼P → ∼Q		1.
2.	∼P	ACD	2.
3.	Q → ∼R	Prem 1	3.
4.	∼P → R	Prem 2	4.
5.	~~Sho~~ ∼Q		5.
6.	∼∼Q	AID	6.
7.	Q	6, DN	7.
8.	∼R	3, 7, MT	8.
9.	R	4, 2, MP	9.

Ex #16

i v [✓ s] e

1.	~~Show~~ ∼P → ∼Q		1.
2.	∼P	ACD	2.
3.	Q → ∼R	Prem 1	3.
4.	∼P → R	Prem 2	4.
5.	~~Sho~~ ∼Q		5.
6.	Q	AID	6.
7.	∼R	3, 6, MP	7.
8.	R	4, 2, MP	8.

Ex #16

i v s [✓ e]

1.	~~Show~~ ∼P → ∼Q		1.
2.	∼P	ACD	2.
3.	Q → ∼R	Prem 1	3.
4.	∼P → R	Prem 2	4.
5.	R	4, 2, MP	5.
6.	∼∼R	5, DN	6.
7.	∼Q	3, 6, MT	7.

Ex #17

i v [✓ s] e

1.	~~Show~~ P		1.
2.	~P	AID	2.
3.	~(R → Q)	Prem 1	3.
4.	Q	Prem 2	4.
5.	~~Sho~~ R → Q		5.
6.	R	ACD	6.
7.	Q	4, R	7.

Ex #17

i v s [✓ e]

1.	~~Show~~ P		1.
2.	~(R → Q)	Prem 1	2.
3.	~~Sho~~ R → Q		3.
4.	Q	Prem 2	4.

Ex #18

i v s [✓ e]

1.	~~Show~~ ~P		1.
2.	P	AID	2.
3.	P → Q	Prem 1	3.
4.	P → ~Q	Prem 2	4.
5.	Q	3, 2, MP	5.
6.	~Q	4, 2, MP	6.

Lesson 3. pp. 29-30

#19--solved in textbook

#20. Scheme of abbreviation:

P: Alfred studies
Q: Alfred recieves good grades
R: Alfred enjoys college

Premise 1. If Alfred studies, then he recieves good grades. P → Q.
Premise 2. If he does not study, then he enjoys college. ~P Θ R
Premise 3. If he doesn't recieve good grades, then he does not enjoy college. ~Q → ~R

Conclusion: Alfred recieves good grades. Q

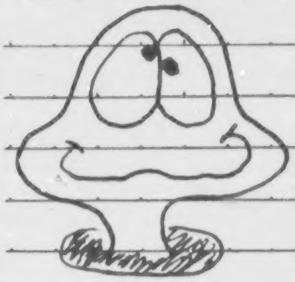
i v s [✓ e]

1.	~~Show:~~ Q		1.
2.	$\sim Q$	AID	2.
3.	$P \to Q$	Prem 1	3.
4.	$\sim P \to R$	Prem 2	4.
5.	$\sim Q \to \sim R$	Prem 3	5.
6.	$\sim P$	3, 2, MT	6.
7.	R	4, 6, MP	7.
8.	$\sim\sim R$	7, DN	8.
9.	$\sim\sim Q$	5, 8, MT	9.

#21 Scheme of abbreviation:

P: Herbert can take the apartment
Q: Herbert divorces his wife
R: Herbert should think twice
S: Herbert keeps Fido
T: Herbert's wife insists on keeping Fido

Premise 1. If Herbert can take the aparement only if he divorces his wife, then he should think twice. $(P \to Q) \to R$
Premise 2. If Herbert keeps Fido, then he cannot take the apartment. $S \to \sim P$
Premise 3. Herbert's wife insists on keeping Fido. T
Premise 4. If Herbert does not keep Fido, then he will divorce his wife provided that she insists on keeping Fido. $\sim S \to (T \to Q)$
Conclusion. Herbert should think twice. R



Now for the Proof!

Hang On!

i v s ⓔ

1.	~~Show~~ R		1.
2.	~~Sho~~ P → Q		2.
3.	P	ACD	3.
4.	∼∼P	3, DN	4.
5.	S → ∼P	Prem 2	5.
6.	∼S	5, 4, MT	6.
7.	∼S → (T → Q)	Prem 4	7.
8.	T → Q	7, 6, MP	8.
9.	T	Prem 3	9.
10.	Q	8, 9, MP	10.
11.	(P → Q) → R	Prem 1	11.
12.	R	11, 2, MP	12.

#22 Scheme of abbreviation:

P: Herbert grows rich
Q: Herbert can take the apartment
R: Herbert divorces his wife
S: Herbert will recieve his inheritance
T: Fido matters

Premise 1. If Herbert grows rich, then he can take the apartment. P → Q
Premise 2. If he divorces his wife, then he will not recieve his inheritance. R → ∼S
Premise 3. Herbert will grow rich if he recieves his inheritance. S → P
Premise 4. Herbert can take the apartment only if he divorces his wife. Q → R

Conclusion. If Herbert receives his inheritance, then Fido does not matter. S → ∼T i v s ⓔ

1.	~~Show~~ $S \rightarrow \sim T$	
2.	S	ACD
3.	$S \rightarrow P$	Prem 3
4.	P	3, 2, MP
5.	$P \rightarrow Q$	Prem 1
6.	Q	5, 4, MP
7.	$Q \rightarrow R$	Prem 4
8.	R	7, 6, MP
9.	$R \rightarrow \sim S$	Prem 2
10.	$\sim S$	9, 8, MP

#23. *This exercises is excluded by constitutional law from use in publicly supported institutions. Its validity's investigation is left to the theologically curious!*

#24. Scheme of abbreviation:

P: Business will flourish
Q: Taxes will increase
R: The standard of living will improve
S: Unemployment will be a problem

Premise 1. If business will flourish on the condition that taxes will not increase, then the standard of living will improve. $(\sim Q \rightarrow P) \rightarrow R$

Premise 2. It is not the case that the standard of living will improve. $\sim R$

Premise 3. If business does not flourish, then taxes will increase. $P \rightarrow Q$

Conclusion. Unemployment will be a problem. S

i v s ⓔ

1.	~~Show~~ S	
2.	$(\sim Q \rightarrow P) \rightarrow R$	Prem 1
3.	$\sim R$	Prem 2
4.	$\sim(\sim Q \rightarrow P)$	2, 3, MT
5.	~~Sho~~ $\sim Q \rightarrow P$	
6.	$\sim Q$	ACD
7.	$\sim P \rightarrow Q$	Prem 3
8.	$\sim\sim P$	7, 6, MT
9.	P	8, DN

#25. Scheme of abbreviation:

P: The standard of living will improve
Q: Taxes will increase
R: Business will flourish
S: Unemployment is a problem

Premise 1. The standard of living will improve provided that taxes will increase. $Q \rightarrow P$

Premise 2. Business will flourish only if unemployment is not a problem. $R \rightarrow \sim S$

Premise 3. Busines will flourish if the standard of living will improve. $P \rightarrow R$

Conclusion. On the condition that taxes will increase, unemployment is not a problem. $Q \rightarrow \sim S$

i v s [✓ e]

1.	~~Show~~ $Q \rightarrow \sim S$		1.
2.	Q	ACD	2.
3.	$Q \rightarrow P$	Prem 1	3.
4.	$R \rightarrow \sim S$	Prem 2	4.
5.	$P \rightarrow R$	Prem 3	5.
6.	P	3, 2, MP	6.
7.	R	5, 7, MP	7.
8.	$\sim S$	4, 7, MP	8.

Lesson 4. p. 37

Ex #26 Th: 4

i v s [✓ e]

1.	~~Show:~~ $(P \rightarrow Q) \rightarrow ([Q \rightarrow R] \rightarrow [P \rightarrow R])$		1.
2.	$P \rightarrow Q$	ACD	2.
3.	~~Sho~~ $[Q \rightarrow R] \rightarrow [P \rightarrow R]$		3.
4.	$Q \rightarrow R$	ACD	4.
5.	~~Sho~~ $P \rightarrow R$		5.
6.	P	ACD	6.
7.	Q	2, 6, MP	7.
8.	R	4, 7, MP	8.

Th' 7

i v [✓ s]* e

1.	~~Show~~ ([P → Q] → [P → R]) → (P → [Q → R])		1.
2.	[P → Q] → [P → R]	ACD	2.
3.	-Sho- P → [Q → R]		3.
4.	P	ACD	4.
5.	-Sho- Q → R		5.
6.	Q	ACD	6.
7.	-Sho- P → Q		7.
8.	P	ACD	8.
9.	Q	6, R	9.
10.	P → R	2, 7, MP	10.
11.	R	10, 4, MP	11.

**The superior student can announce his/her talent by showing how this merely standard proof can be gussied up into an elegant one!*

Th' 15

i v s [✓ e]

1.	Show (∼P → Q) → (∼Q → P)		1.
2.	∼P → Q	ACD	2.
3.	-Sho- ∼Q → P		3.
4.	∼Q	ACD	4.
5.	∼∼P	2, 4, MT	5.
6.	P	5, DN	6.

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Ex #27 Th' 18

i v s [✓ e]

1.	~~Show~~ ∼P → (P → Q)		1.
2.	∼P	ACD	2.
3.	~~Sho~~ P → Q		3.
4.	P	ACD	4.
5.	∼∼P	2, R	5.

DISCUSSION QUESTION FOR THE LOGICAL AESTHETE:

Which of the following proofs of T20 is more elegant?

Th' 20

i v s [✓ e]

1.	~~Show~~ (P → ∼P) → ∼P		1.
2.	P → ∼P	ACD	2.
3.	~~Sho~~ ∼P		3.
4.	P	AID	4.
5.	∼P	2, 4, MP	5.

Th' 20

i v s [✓ e]

1.	~~Show~~ (P → ∼P) → ∼P		1.
2.	P → ∼P	~~ACD~~	2.
3.	~~Sho~~ ∼P		3.
4.	∼∼P	AID	4.
5.	∼P	2, 4, MT	5.

Th' 21

i v s [✓ e]

1.	~~Show~~' ∼(P → Q) → P		1.
2.	∼(P → Q)	ACD	2.
3.	~~Sho~~ P		3.
4.	∼P	AID	4.
5.	~~Sho~~ P → Q		5.
6.	P	ACD	6.
7.	∼P	4, R	7.
8.	∼(P → Q)	2, R	8.

Th' 22

i v s [✓ e]

1.	~~Show~~' ∼(P → Q) → Q		1.
2.	∼(P → Q)	ACD	2.
3.	~~Sho~~ ∼Q		3.
4.	Q	AID	4.
5.	~~Sho~~ P → Q		5.
6.	Q	4, R	6.
7.	∼(P → Q)	2, R	7.

UNIT II

Lesson 5. p. 42

#7. ((Q v R) → ((P ∧ R) → (Q ↔ (R v P))))

#8. (((P ∧ Q) v (∼P ∧ ∼Q)) → ((P ↔ Q) ↔ (Q ↔ P)))

#9. (((P → (Q v R)) v ((Q v R) → P)) ↔ ((Q v P) ↔ P))

#10. (∼((P v (Q ∧ R)) → (((P v Q) ∧ (P v R)) ↔ (P ∧ Q))) pp. 45-47

#13. Assuming that logic is difficult or that the text is not readable, Alfred will pass only if he concentrates.
(1) (If (logic is difficult or it is not the case that the text is readable) then (if Alfred will pass, then Alfred concentrates))
(2a) ((logic is difficult v ∼the text is readable) → (Alfred will pass →Alfred concentrates))
(2b) $((P \vee \sim Q) \rightarrow (R \rightarrow S))$
(2c) $(p \vee \sim Q) \rightarrow (R \rightarrow S)$

#14 Unless logic is difficult, Alfred will pass if he concentrates.
(1) (Logic is difficult or (if Alfred will pass, then Alfred concentrates))
(2a) (Logic is difficult v (Alfred will pass → Alfred concentrates))
(2b) $(P \vee (R \rightarrow S))$
(2c) $P \vee (R \rightarrow S)$

#15 Mary will arrive at 10:30 A.M unless the plane is late.
(1) (Mary will arrive at 10:30 A.M. or the plane is late)
(2a) (Mary will arrive at 10:30 A.M. v the plane is late)
(2b) $(P \vee Q)$
(2c) $P \vee Q$

#16 Assuming that the professor is a Communist, he will sign the loyalty oath; but if he is an idealist, he will neither sign the loyalty oath nor speak to those that do.
(1) ((if the professor is a Communist, then the professor will sign the loyalty oath) and (if the professor is an idealist, then (it is not the case that the professor will sign the loyalty oath and it is not the case that the professor will speak to those who sign the loyalty oath)))
(2a) (((the professor is a Communist → the professor will sign the loyalty oath) ∧ (the professor is an idealist →(∼the professor will sign the loyalty oath ∧ ∼the professor will speak to those who sign the loyalty oath)))
(2b) $((P \rightarrow Q \wedge (R \rightarrow (\sim Q \wedge \sim S)))$
(2c) $(P \rightarrow Q) \wedge (R \rightarrow [\sim Q \wedge \sim S])$

#17 If Alfred and Mary are playing dice together, it is the first throw of the game, and Mary is throwing the dice, then she wins on the first throw if and only if she throws 7 or 11.
(1) (if(Alfred and Mary are playing dice together and it is the first throw of the game) and Mary is throwing the dice,) then (Mary wins the game on the first throw if and only if (Mary throws 7 or Mary throws 11)))
(2a) (((Alfred and Mary are throwing dice together ∧ it is the first throw of the game) ∧ Mary is throwing the dice) → (Mary wins the game on the first throw ↔ (Mary throws 7 v Mary throws 11)))
(2b) $(((R \wedge S) \wedge T) \rightarrow (U \leftrightarrow (W \vee X)))$
(2c) $R \wedge S \wedge T \rightarrow (U \leftrightarrow [W \vee X])$

#18 If the world is a progressively realized community of interpretation, then either quadruplicity will drink procrastination or, provided that the Nothing negates, boredom will ensue seldom more often than frequently.

(1) (if the world is a progressivly realized community of interpretation, then (quadruplicity will drink procrastination or (if the Nothing negates, then boredom will ensue seldom more often than frequently)))

(2a) (the world is a progressively realized community of interpretation → (quadruplicity will drink procrastination v (the Nothing negates → boredom will ensue seldom more often than frequently)))

(2b) $(P \to (Q \vee (R \to S)))$

(2c) $P \to (Q \vee [R \to S])$

#20 $(P \vee Q) \to \sim(R \vee [S \wedge T]) \vee (U \wedge V)$

$([P \vee Q] \to \sim[R \vee \{S \wedge T\}]) \vee (U \wedge V)$

#21 $P \to (\sim[S \vee T\} \to [Q \to R])$

$P \to (\sim S \vee T \to [Q \to R])$

Lesson 6. p. 55

Ex # 22 Th' 28

i v s ⓔ

1.	~~Show~~ (P ∧ Q → R) ↔ (P ∧ ∼R → ∼Q)	
2.	-~~Sho~~- →	
3.	P ∧ Q → R	ACD
4.	-~~Sho~~- P ∧ ∼R → ∼Q	
5.	P ∧ ∼R	ACD
6.	-~~Sho~~- ∼Q	
7.	Q	AID
8.	P	5, S
9.	∼R	5, S
10.	P ∧ Q	7,8, Adj.
11.	R	3, 10,MP
12.	~~Sho~~- ←	
13.	P ∧ ∼R → ∼Q	ACD
14.	-~~Sho~~- P ∧ Q → R	
15.	P ∧ Q	ACD
16.	-~~Sho~~- R	
17.	∼R	AID
18.	P	15, S
19.	Q	15, S
20.	P ∧ ∼R	18, 17, Adj
21.	∼Q	13, 20, MP
22.	↔	2, 12, CB
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Th! 29

i v s ⓔ

1.	~~Show~~ $(P \to Q \wedge R) \leftrightarrow (P \to Q) \wedge (P \to R)$	
2.	~~Sho~~ $\to$	
3.	$P \to Q \wedge R$	ACD
4.	~~Sho~~ $P \to Q$	
5.	P	ACD
6.	$Q \wedge R$	3, 5, MP
7.	Q	6, R
8.	~~Sho~~ $P \to R$	
9.	P	ACD
10.	$Q \wedge R$	3, 9, MP
11.	R	10, S
12.	$(P \to Q) \wedge (P \to R)$	4, 8, Adj
13.	~~Sho~~ $\leftarrow$	
14.	$(P \to Q) \wedge (P \to R)$	ACD
15.	~~Sho~~ $P \to Q \wedge R$	
16.	P	ACD
17.	$P \to Q$	14, S
18.	$P \to R$	14, S
19.	Q	17, 16, MP
20.	R	18, 16, MP
21.	$Q \wedge R$	19, 20, Adj
22.	$\leftrightarrow$	2, 13, CB

Th: 34

i v s [✓ e]

1.	~~Show~~ (P → Q) ∧ (P → ∼Q) → ∼P	
2.	(P → Q) ∧ (P → ∼Q)	ACD
3.	P → Q	2, S
4.	P → ∼Q	2, S
5.	~~Sho~~ ∼P	
6.	P	AID
7.	Q	3, 6, MP
8.	∼Q	4, 6, MP
9.		
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Ex #23 Th' 38

i v s ⓔ

1.	~~Show~~ P ∧ Q ↔ ∼(P → ∼Q)	
2.	~~Sho~~ →	
3.	P ∧ Q	ACD
4.	~~Sho~~ ∼(P → ∼Q)	
5.	P → ∼Q	AID
6.	P	3, S
7.	Q	3, S
8.	∼Q	5, 6, MP
9.	~~Sho~~ ←	
10.	∼(P → ∼Q)	ACD
11.	~~Sho~~ P	
12.	∼P	AID
13.	~~Sho~~ P → ∼Q	
14.	P	ACD
15.	∼P	12, R
16.	∼(P → ∼Q)	10, R
17.	~~Sho~~ Q	
18.	∼Q	AID
19.	~~Sho~~ P → ∼Q	
20.	∼Q	18, R
21.	∼(P → ∼Q)	10, R
22.	P ∧ Q	11, 17, Adj
23.	↔	2, 9, CB

Th' 44

i v s ⓔ

1.	~~Show~~ ∼Q → ∼(P ∧ Q)	
2.	∼Q	ACD
3.	~~Sho~~ ∼(P ∧ Q)	
4.	P ∧ Q	AID
5.	Q	4, S
6.	∼Q	2, R

[P. 20,1 follows.]

Lesson 6. pp. 68-69. #29

1.	~~-Sho-~~ $(P \leftrightarrow Q) \leftrightarrow (P \wedge Q) \vee (\sim P \wedge \sim Q)$	
2.	~~-Sho-~~ $\rightarrow$	
3.	$P \leftrightarrow Q$	ACD
4.	~~-Sho-~~ $\sim(P \wedge Q) \rightarrow \sim P \wedge \sim Q$	
5.	$\sim(P \wedge Q)$	ACD
6.	~~-Sho-~~ $\sim P$	
7.	P	AID
8.1	$P \rightarrow Q$	3, BC
8.2	Q	8.1, 7, MP
8.3	$P \wedge Q$	8.2, 7, Adj
9.	$\sim(P \wedge Q)$	5, R
10.1	$Q \rightarrow P$	3, BC
10.2	$\sim Q$	10.1, 6, MT
10.3	$\sim P \wedge \sim Q$	6, 10.2, Adj
11.	$(P \wedge Q) \vee (\sim P \wedge \sim Q)$	4, CD
12.	~~-Sho-~~ $P \wedge Q \rightarrow (P \leftrightarrow Q)$	
13.	$P \wedge Q$	ACD
14.1	Q	13, S
14.2	$Q \rightarrow (P \rightarrow Q)$	T2
14.3	$P \rightarrow Q$	14.1, 14.2, MP
14.4	P	13, S
14.5	$P \rightarrow (Q \rightarrow P)$	T2, P/Q, Q/P
14.6	$Q \rightarrow P$	14.5, 14.4, MP
14.7	$P \leftrightarrow Q$	14.3, 14.3, CB
15	~~-Sho-~~ $\sim P \wedge \sim Q \rightarrow (P \leftrightarrow Q)$	
16	$\sim P \wedge \sim Q$	ACD
17.1	$\sim P$	16, S
17.2	$\sim P \rightarrow (P \rightarrow Q)$	T18
17.3	$P \rightarrow Q$	17.2, 17.1, MP
17.4	$\sim Q$	16, S
17.5	$\sim Q \rightarrow (Q \rightarrow P)$	T18, P/Q, Q/P
17.6	$Q \rightarrow P$	17.5, 17.4, MP
17.7	$P \leftrightarrow Q$	17.3, 17.6, CB
18.1	$(P \wedge Q) \vee (\sim P \wedge \sim Q) \rightarrow (P \leftrightarrow Q)$	12, 15, SC
18.2	$(P \leftrightarrow Q) \leftrightarrow (P \wedge Q) \vee (\sim P \wedge \sim Q)$	2, 18.1, CB

Lesson 6. pp. 68-69

Ex # 30 Th' 55

i v s [✓ e]

1.	~~Show~~ ∼(P → Q v R) ↔ (P → Q) v (P → R)		1.
2.	-~~Sho~~- →		2.
3.	P → Q v R	ACD	3.
4.	-~~Sho~~- ∼(P → Q) → (P → R)		4.
5.	∼(P → Q)	ACD	5.
6.	P → R	T40, BC, 5, MP, S, 3, MP, T40, S, MP, MTP, T2, Q/R, MP	6.
7.	(P → Q) v (P → R)	4, CD	7.
8.	-~~Sho~~- ←		8.
9.	(P → Q) v (P → R)	ACD	9.
10.	-~~Sho~~- P → Q v R		10.
11.	P	ACD	11.
12.	-~~Sho~~- ∼Q → R	ACD	12.
13.	∼Q	ACD	13.
14.	R	11, 13, adj, T40, BC, MP, 9, MTP, 11, MP	14.
15.	Q v R	12, CD	15.
16.	↔	2, 8, CD	16.

Th' 58

i v s [✓ e]

1.	~~Show~~ (P → Q) v (Q → R)		1.
2.	-~~Sho~~- ∼(P → Q) → (Q → R)		2.
3.	∼(P → Q)	ACD	3.
4.	Q → R	T40, CB, 2, MP, S, T18, P/Q, Q/R, MP	4.
5.	(P → Q) v (Q → R)	2, CD	5.

Th' 60

i v s ⓔ

1. Show' $(P \to R) \lor (Q \to R) \leftrightarrow (P \land Q \to R)$
2. ~~Sho~~ $\to$
3. $(P \to R) \lor (Q \to R)$ ACD
4. ~~Sho~~ $P \land Q \to R$
5. $P \land Q$ ACD
6. R 5, S, 5, S, 3, SC
7. ~~Sho~~ $\leftarrow$
8. $P \quad Q \to R$ ACD
9. ~~Sho~~ $\sim(P \to R) \to (Q \to R)$
10. $\sim(P \to R)$ ACD
11. ~~Sho~~ $Q \to R$
12. Q ACD
13. R T40, Q/R, BC, 10, MP, S, 12, Adj, 8, MP
14. $(P \to R) \lor (Q \to R)$
15. $\leftrightarrow$ 2, 7, CB

Th' 61

i v s [✓ e]

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 1. ~~Show'~~- P ∧ (Q v R) ↔ (P ∧ Q) v (P ∧ R)
 2.   -Sho-  →
 3.     P ∧ (Q v R)                              ACD
 4.       -Sho- ∿(P ∧ Q) → (P ∧ R)
 5.         ∿(P ∧ Q)                             ACD
 6.           -Sho- R
 7.             ∿R                               AID
 8.             P ∧ Q                            3, S, 7, MTP, 3, 5, S, Adj
 9.             ∿(P ∧ Q)                         5, R
10.         P ∧ R                                3, S, 6, Adj
11.       (P ∧ Q) v (P ∧ R)                      4, CD
12.   -Sho  ←
13.     (P ∧ Q) v (P ∧ R)                        ACD
14.       -Sho-  P
15.         ∿P                                   AID
16.         P                 T43, 15, MP, 13, MTP, S
17.       -Sho-  ∿Q → R
18.         ∿Q                                   ACD
19.         R                                    T44, 18, MP, 13, MTP, S
20.       P ∧ (Q v R)                            17, CD, 4, Adj
21.   ↔                                          2, 12, CB
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Polecat Logic Derivation Sheet

Th' 62

i v s ⓔ

1.	~~Show~~ P v (Q ∧ R) ↔ (P v Q) ∧ (P v Q)	
2.	-Sho- →	
3.	P v (Q ∧ R)	ACD
4.	-Sho- ∿P → Q	
5.	∿P	ACD
6.	Q	3, 5, MTP, S
7.	-Sho- ∿P → R	
8.	∿P	ACD
9.	R	3, 8, MTP, S
10.	(P v Q) ∧ (P v R)	4, CD, 7, CD, Adj
11.	-Sho- ←	
12.	(P v Q) ∧ (P R)	ACD
13.	-Sho- ∿P → (Q ∧ R)	
14.	∿P	ACD
15.	Q ∧ R	12, S, 14, MTP, 12, S, 14, MTP, Adj
16.	P v (Q ∧ R)	13, CD
17.	↔	2, 11, CB

Ex #31 Th 63

i v s [✓ e]

1.	~~Show~~ P ∧ Q ↔ ∼(∼P v ∼Q)	
2.	-Sho- →	
3.	P ∧ Q	ACD
4.	-Sho- ∼(∼P v ∼Q)	
5.	∼P v ∼Q	AID
6.	Q	3, S
7.	∼Q	3, S, DN, 5, MTP
8.	-Sho- ←	
9.	∼(∼P v ∼Q)	ACD
10.	-Sho- P	
11.	∼P	AID
12.	∼P v ∼Q	11, Add
13.	∼(∼P v ∼Q)	9, R
14.	-Sho- Q	
15.	∼Q	AID
16.	∼P v ∼Q	15, Add
17.	∼(∼P v ∼Q)	9, R
18.	P ∧ Q	10, 14, Adj
19.	↔	2, 8, CB

Th: 64

i v s ⓔ

1.	~~Show~~ P v Q ↔ ∼(∼P ∧ ∼Q)	
2.	~~Sho~~ →	
3.	P v Q	ACD
4.	~~Sho~~ ∼(∼P ∧ ∼Q)	
5.	∼P ∧ ∼Q	AID
6.	Q	5, S, 3, MTP
7.	∼Q	5, S
8.	~~Sho~~ ←	
9.	∼(∼P ∧ ∼Q)	ACD
10.	~~Sho~~ ∼P → Q	
11.	∼P	ACD
12.	~~Sho~~ Q	
13.	∼Q	AID
14.	∼P ∧ ∼Q	11, 13, Adj
15.	∼(∼P ∧ ∼Q)	9, R
16.	P v Q	10, CD
17.	↔	2, 8, CB
18.		
19.		
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Th' 68

i v s [✓ e]

1.	~~-Show-~~ P ↔ (P ∧ Q) v (P ∧ ~Q)		1.
2.	-Sho- →		2.
3.	P	ACD	3.
4.	-Sho- ~(P ∧ Q) → (P ∧ ~Q)		4.
5.	~(P ∧ Q)	ACD	5.
6.	P ∧ ~Q	T39, BC, 5, MP, 3, MP, Adj	6.
7.	(P ∧ Q) v (P ∧ ~Q)	4, CD	7.
8.	-Sho- ←		8.
9.	(P ∧ Q) v (P ∧ ~Q)	ACD	9.
10.	-Sho- P		10.
11.	~P	AID	11.
12.	P	T43, 11, MP, 9, MTP, S	12.
13.	↔	2, 8, BC	13.

Th' 69

i v s [✓ e]

1.	~~-Show-~~ P ↔ (P v Q) ∧ (P v ~Q)		1.
2.	-Sho- →		2.
3.	P	ACD	3.
4.	(P v Q) ∧ (P v ~Q)	3, Add, 3, Add, Adj	4.
5.	-Sho- ←		5.
6.	(P v Q) ∧ (P v ~Q)	ACD	6.
7.	-Sho- P		7.
8.	~P	AID	8.
9.	Q	6, S, 8, MTP	9.
10.	~Q	6, S, 8, MTP	10.
11.	↔	2, 5, CB	11.

Ex #32 Th' 70

i v s [✓ e]

1.	~~Show~~ $Q \rightarrow (P \wedge Q \leftrightarrow P)$		1.
2.	Q	ACD	2.
3.	~~Sho~~ $P \wedge Q \rightarrow P$		3.
4.	$P \wedge Q$	ACD	4.
5.	P	4, S	5.
6.	~~Sho~~ $P \rightarrow P \wedge Q$		6.
7.	P	ACD	7.
8.	$P \wedge Q$	7, 2, Adj	8.
9.	$P \wedge Q \leftrightarrow P$	3, 6, CB	9.

Th' 71

i v s [✓ e]

1.	~~Show~~ $\sim Q \rightarrow (P \vee Q \leftrightarrow P)$		1.
2.	$\sim Q$	ACD	2.
3.	~~Sho~~ $P \vee Q \rightarrow P$		3.
4.	$P \vee Q$	ACD	4.
5.	P	4, 2, MTP	5.
6.	~~Sho~~ $P \rightarrow P \vee Q$		6.
7.	P	ACD	7.
8.	$P \vee Q$	7, Add	8.
9.	$P \vee Q \leftrightarrow P$	3, 6, CB	9.

Th' 72

i v s [✓ e]

1.	~~Show~~ $(P \to Q) \leftrightarrow (P \wedge Q \leftrightarrow P)$		1.
2.	-Sho- $\to$		2.
3.	$P \to Q$	ACD	3.
4.	-Sho- $P \wedge Q \to P$		4.
5.	$P \wedge Q$	ACD	5.
6.	P	5, S	6.
7.	-Sho- $P \to P \wedge Q$		7.
8.	P	ACD	8.
9.	$P \wedge Q$	3, 8, MP, 8, Adj	9.
10.	$P \wedge Q \leftrightarrow P$	4, 7, CB	10.
11.	-Sho- $\leftarrow$		11.
12.	$P \wedge Q \leftrightarrow P$	ACD	12.
13.	-Sho- $P \to Q$		13.
14.	P	ACD	14.
15.	Q	12, BC, 14, MP, S	15.
16.	$\leftrightarrow$	2, 11, CB	16.

Th: 73

i v s ⓔ

1.	~~Show~~ (P → Q) ↔ (P v Q ↔ Q)	
2.	~~-Sho-~~ →	
3.	P → Q	ACD
4.	~~-Sho-~~ P v Q → Q	
5.	P v Q	ACD
6.	Q	T45, BC, 5, MP, 3, Adj, T33, MP
7.	~~-Sho-~~ Q → P v Q	
8.	Q	ACD
9.	P v Q	8, Add
10.	P v Q ↔ Q	4, 7, CB
11.	~~-Sho-~~ ←	
12.	P v Q ↔ Q	ACD
13.	~~Sho~~ P → Q	
14.	P	ACD
15.	Q	12, BC, 14, Add, MP
16.	↔	2, 11, CB

Th! 78

i v s ⓔ

1.	-Show!- (P → [Q ↔ R]) ↔ ([P → Q] ↔ [P → R])	
2.	-Sho- →	
3.	P → [Q ↔ R]	ACD
4.	-Sho- [P → Q] → [P → R]	
5.	P → Q	ACD
6.	-Sho- P → R	
7.	P	ACD
8.	R	3, 7, MP, BC, 5, 7, MP, MP
9.	-Sho- [P → R] → [P → Q]	
10.	P → R	ACD
11.	-Sho- P → Q	
12.	P	ACD
13.	Q	3, 12, MP, BC, 10, 12, MP, MP
14.	[P → Q] ↔ [P → R]	4, 9, CB
15.	-Sho- ←	
16.	[P → Q] ↔]P → R]	ACD
17.	-Sho- P → [Q ↔ R]	
18.	P	ACD
19.	-Sho- Q → R	
20.	Q	ACD
21.	R	T2, 20, MP, 16, BC, MP, 18, MP
22.	-Sho- R → Q	
23.	R	ACD
24.	Q	T2, Q/R, 23, MP, 16, BC, MP, 18, MP
25.	Q ↔ R	19, 22, CB
26.	↔	2, 15, CB
27.		
28.		
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Polecat Logic Derivation Sheet

Th! 79

i v [✓ s] e

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1.  ~~Show!~~ (P → [Q ↔ R]) ↔ (P ∧ Q ↔ P ∧ R)
2.    -Sho- →
3.      P → [Q ↔ R]                                              ACD
4.        -Sho- P ∧ Q → P ∧ R
5.          P ∧ Q                                                ACD
6.          P ∧ R            5, S, 3, MP, BC, 5, S, MP, Adj
7.        -Sho- P ∧ R → P   Q
8.          P ∧ R                                                ACD
9.          P ∧ Q            8, S, 3, MP, BC, 8, S, MP, Adj
10.       P ∧ Q ↔ P ∧ R                                          4, 7, CB
11.   -Sho- ←
12.     P ∧ Q ↔ P ∧ R                                            ACD
13.       -Sho- P → [Q ↔ R]
14.         P                                                    ACD
15.           -Sho- Q → R
16.             Q                                                ACD
17.             R            14, 16, Adj, 12, BC, MP, S
18.           -Sho- R → Q
19.             R                                                ACD
20.             Q            14, 19, Adj, 12, BC, MP, S
21.         Q ↔ R                                                15, 18, CB
22.   ↔                                                          2, 11, CB
23.
24.
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Th 80

i v s e

1.	~~Show~~ $(P \leftrightarrow Q) \vee (P \leftrightarrow \sim Q)$	
2.	~~Sho~~ $\sim(P \leftrightarrow Q) \rightarrow (P \leftrightarrow \sim Q)$	
3.	$\sim(P \leftrightarrow Q)$	ACD
4.	~~Sho~~ $P \rightarrow \sim Q$	
5.	P	ACD
6.	~~Sho~~ $\sim Q$	
7.	Q	AID
8.	$P \leftrightarrow Q$	T2, 5, MP, T2, P/Q , Q/P, 7, MP, CB
9.	$\sim(P \leftrightarrow Q)$	3, R
10.	~~Sho~~ $\sim Q \rightarrow P$	
11.	$\sim Q$	ACD
12.	~~Sho~~ P	
13.	$\sim P$	AID
14.	$P \leftrightarrow Q$	T18, 13, MP, T18, P/Q, Q/P, 11, MP, CB
15.	$\sim(P \leftrightarrow Q)$	3, R
16.	$(P \leftrightarrow \sim Q)$	4, 10, CB
17.	$(P \leftrightarrow Q) \vee (P \leftrightarrow \sim Q)$	2, CD

Polecat Logic Derivation Sheet

Ex #34   Th: 86

i v s ⓔ

1.	~~Show~~ – $([P \leftrightarrow Q] \to R) \leftrightarrow (P \wedge Q \to R) \wedge (\sim P \wedge \sim Q \to R)$	
2.	-Sho- $\to$	
3.	$[P \leftrightarrow Q] \to R$	ACD
4.	-Sho- $P \wedge Q \to R$	
5.	$P \wedge Q$	ACD
6.	R	T84, 5, MP, 3, MP
7.	-Sho- $\sim P \wedge \sim Q \to R$	
8.	$\sim P \wedge \sim Q$	ACD
9.	R	T85, 8, MP, 3, MP
10.	$(P \wedge Q \to R) \wedge (\sim P \wedge \sim Q \to R)$	4, 7, Adj
11.	-Sho- $\leftarrow$	
12.	$(P \wedge Q \to R) \wedge (\sim P \wedge \sim Q \to R)$	ACD
13.	-Sho- $[P \leftrightarrow Q] \to R$	
14.	$P \leftrightarrow Q$	ACD
15.	$(P \wedge Q) \vee (\sim P \wedge \sim Q)$	T83, BC, 14, MP
16.	R	12, S, 12, S, 15, SC
17.	$\leftrightarrow$	2, 11, CB

Th: 87

Ident:

i v s ⓔ

1.	~~Show:~~ - $\sim(P \leftrightarrow Q) \leftrightarrow (P \wedge \sim Q) \vee (\sim P \wedge Q)$	
2.	-Sho- $\rightarrow$	
3.	$\sim(P \leftrightarrow Q)$	ACD
4.	-Sho- $\sim(P \wedge \sim Q) \rightarrow (\sim P \wedge Q)$	
5.	$\sim(P \wedge \sim Q)$	ACD
6.	$P \rightarrow Q$	T40, BC, 5, MP
7.	-Sho- $\sim P$	4
8.	P	AID
9.	$P \leftrightarrow Q$	6, 8, MP, 8, Adj, T84, MP
10.	$\sim(P \leftrightarrow Q)$	3, R
11.	-Sho- Q	
12.	$\sim Q$	AID
13.	$P \leftrightarrow Q$	7, 12, Adj, T85, MP
14.	$\sim(P \leftrightarrow Q)$	3, R
15.	$\sim P \wedge Q$	7, 11, Adj
16.	$(P \wedge \sim Q) \vee (\sim P \wedge Q)$	4, CD
17.	-Sho- $\leftarrow$	
18.	$(P \wedge \sim Q) \vee (\sim P \wedge Q)$	ACD
19.	-Sho- $\sim(P \leftrightarrow Q)$	
20.	$P \leftrightarrow Q$	AID
21.	$\sim P \wedge Q$	20, S, DN, T40, BC MT, 18, MTP
22.	P	21, S, 20, BC, MP
23.	$\sim P$	21, S
24.	$\leftrightarrow$	2, 17, CB
25.		
26.		
27.		
28.		
29.		
30.		
31.		
32.		

Th' 90

i v s ⓔ

1.	~~Show~~ ∼(P ↔ Q) ↔ (P ↔ ∼Q)	
2.	~~Sho~~ →	
3.	∼(P ↔ Q)	ACD
4.	~~Sho~~ P → ∼Q	
5.	P	ACD
6.	~~Sho~~ ∼Q	
7.	Q	AID
8.	P ↔ Q	5, 7, Adj, T84, MP
9.	∼(P ↔ Q)	3, R
10.	~~Sho~~ ∼Q → P	
11.	∼Q	ACD
12.	~~Sho~~ P	
13.	∼P	AID
14.	P ↔ Q	11, T3, Adj, T85, MP
15.	∼(P ↔ Q)	3, R
16.	P ↔ ∼Q	4, 10, CB
17.	~~Sho~~ ←	
18.	P ↔ ∼Q	ACD
19.	~~Sho~~ ∼(P ↔ Q)	
20.	P ↔ Q	AID
21.	~~Sho~~ Q	
22.	∼Q	AID
23.	Q	18, BC, 22, MP, 20, BC, MP
24.	∼Q	20, BC, 21, MP, 18, BC, MP
25.	↔	2, 17, CB
26.		
27.		
28.		
29.		
30.		
31.		
32.		

Th' 95

i v s ⓔ

1.	Show: (P ↔ Q) ↔ ([P ↔ R] ↔ [Q ↔ R])		1.
2.	-Sho- →		2.
3.	P ↔ Q	ACD	3.
4.	-Sho- [P ↔ R] → [Q ↔ R]		4.
5.	P ↔ R	ACD	5.
6.	-Sho- Q → R		6.
7.	Q	ACD	7.
8.	R	3, BC, 7, MP, 5, BC, MP	8.
9.	-Sho- R → Q		9.
10.	R	ACD	10.
11.	Q	5, BC, 10, MP, 3, BC, MP	11.
12.	Q ↔ R	6, 9, CB	12.
13.	-Sho- [Q ↔ R] → [P ↔ R]		13.
14.	Q ↔ R	ACD	14.
15.	-Sho- P → R		15.
16.	P	ACD	16.
17.	R	3, BC, 16, MP, 14, BC, MP	17.
18.	-Sho- R → P		18.
19.	R	ACD	19.
20.	P	14, BC, 19, MP, 3, BC, MP	20.
21.	P ↔ R	15, 18, CB	21.
22.	[P ↔ R] ↔ [Q ↔ R]	4, 13, CB	22.
23.	-Sho- ←		23.
24.	[P ↔ R] ↔ [Q ↔ R]	ACD	24.
25.	([P ↔ R] ∧ [Q ↔ R) ∨ (∼[P ↔ R] ∧ ∼[Q ↔ R])	T83, P/P ↔ R, Q/Q ↔ R, BC, 24, MP	25.
26.	-Sho- [P ↔ R] ∧ [Q ↔ R] → (P ↔ Q)		26.
27.	[P ↔ R] ∧ [Q ↔ R]	ACD	27.
28.	P ↔ Q	T93, Q/R, R/Q, 27, MP	28.
29.	-Sho- ∼[P ↔ R] ∧ ∼[Q ↔ R] → (P ↔ Q)		29.
30.	∼[P ↔ R] ∧ ∼[Q ↔ R]	ACD	30.
31.	P ↔ Q	T90, Q/R, BC, 30, S, MP, T90, P/Q, Q/R, BC, 30, S, MP, Adj, T93, Q/∼R, R/Q, 24, MP	31.
32.	P ↔ Q	25, 26, 29, SC	32.
33.	↔	2, 23, CB	33.

Ex #35 Th' 97

i v s ⓔ

1.	~~Show~~ $(P \leftrightarrow R) \wedge (Q \leftrightarrow S) \rightarrow ([P \rightarrow Q] \leftrightarrow [R \rightarrow S])$		1.
2.	$(P \leftrightarrow R) \wedge (Q \leftrightarrow S)$	ACD	2.
3.	~~Sho~~ $[P \rightarrow Q] \rightarrow [R \rightarrow S]$		3.
4.	$P \rightarrow Q$	ACD	4.
5.	~~Sho~~ $R \rightarrow S$		5.
6.	R	ACD	6.
7.	S	2, S, BC, 6, MP, 4, MP, 2, S, BC, MP	7.
8.	~~Sho~~ $[R \rightarrow S] \rightarrow [P \rightarrow Q]$		8.
9.	$R \rightarrow S$	ACD	9.
10.	~~Sho~~ $P \rightarrow Q$		10.
11.	P	ACD	11.
12.	Q	2, S, BC, 11, MP, 9, MP, 2, BC, MP	12.
13.	$[P \rightarrow Q] \leftrightarrow [R \rightarrow S]$	2, 8, CB	13.

Th' 98

i v s ⓔ

1.	~~Show~~ $(P \leftrightarrow R) \wedge (Q \leftrightarrow S) \rightarrow (P \wedge Q \leftrightarrow R \wedge S)$		1.
2.	$(P \leftrightarrow R) \wedge (Q \leftrightarrow S)$	ACD	2.
3.	~~Sho~~ $P \wedge S \rightarrow R \wedge S$		3.
4.	$P \wedge Q$	ACD	4.
5.	$R \wedge S$	2, S, BC, 4, S, MP, 2, S, BC, 4, s, MP, Adj	5.
6.	~~Sho~~ $R \wedge S \rightarrow P \wedge Q$		6.
7.	$R \wedge S$	ACD	7.
8.	$P \wedge Q$	2, S, BC, 7, S, MP, 2, S, BC, 7 , S, MP, Adj	8.
9.	$P \wedge Q \leftrightarrow R \wedge S$	3, 6, CB	9.

Th' 99

i v s ⓔ

1.	~~Show~~ $(P \leftrightarrow R) \wedge (Q \leftrightarrow S) \rightarrow (P \vee Q \leftrightarrow R \vee S)$	
2.	$(P \leftrightarrow R) \wedge (Q \leftrightarrow S)$	ACD
3.	~~Sho~~ $P \vee Q \rightarrow R \vee S$	
4.	$P \vee Q$	ACD
5.	~~Sho~~ $\sim R \rightarrow S$	
6.	$\sim R$	ACD
7.	S	2, S, BC, 6, MT, 4, MTP, 2, S, BC, MP
8.	$R \vee S$	5, CD
9.	~~Sho~~ $R \vee S \rightarrow P \vee Q$	
10.	$R \vee S$	ACD
11.	~~Sho~~ $\sim P \rightarrow Q$	
12.	$\sim P$	ACD
13.	Q	2, S, BC, 12, MT, 10, MTP, 2, S, BC, MP
14.	$P \vee Q$	11, CD
15.	$P \vee Q \leftrightarrow R \vee S$	3, 9, CB

Th: 100

i v s ⓔ

```
 1. ~~Show~~ (P ↔ R) ∧ (Q ↔ S) → ([P ↔ Q] ↔ [R ↔ S])                                  1.
 2.   (P ↔ R) ∧ (Q ↔ S)                                   ACD                        2.
 3.   -Sho-  [P ↔ Q] → [R ↔ S]                                                        3.
 4.     P ↔ Q                                             ACD                        4.
 5.       -Sho-  R → S                                                                5.
 6.         R                                             ACD                        6.
 7.         S                    2, S, BC, 6, MP, 4, BC, MP, 2, BC, MP               7.
 8.       -Sho-  S → R                                                                8.
 9.         S                                             ACD                        9.
10.         R                    2, S, BC, 9, MP, 4, BC, MP, 2, S, MP               10.
11.     R ↔ S                                             5, 8, CB                  11.
12.   -Sho-  [R ↔ S] → [P ↔ Q]                                                       12.
13.     R ↔ S                                             ACD                       13.
14.       -Sho-  P → Q                                                               14.
15.         P                                             ACD                       15.
16.         Q                    2, S, BC, 15, MP, 13, BC, MP, 2, S, MP             16.
17.       -Sho-  Q → P                                                               17.
18.         Q                                             ACD                       18.
19.         P                    2, S, BC, 18, MP, 13, BC, MP, 2, S, MP             19.
20.     P ↔ Q                                             14, 17, CB                20.
21.   [P ↔ Q] ↔ [Q ↔ S]                                   3, 12, CB                 21.
22.                                                                                 22.
23.                                                                                 23.
24.                                                                                 24.
25.                                                                                 25.
26.                                                                                 26.
27.                                                                                 27.
28.                                                                                 28.
29.                                                                                 29.
30.                                                                                 30.
31.                                                                                 31.
32.                                                                                 32.
```

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Polecat Logic Derivation Sheet

Lesson 8. pp. 71-72

#36 Scheme of abbreviation: P--Mary joins a sorority; Q--Mary givens in to her inclinations; R--Mary's social life will flourish; S--Mary's academic life will suffer

Premise 1. $P \wedge Q \rightarrow R$
Premise 2. $R \rightarrow S$
Premise 3. $Q \wedge \sim S$
Conclusion. $\sim P$

1.	~~Sho~~ $\sim P$		1.
2.	P	AID	2.
3.	S	Prem 3, S, 2, Adj, Prem 1, MP, Prem 2, MP	3.
4.	$\sim S$	Prem 3, S	4.

#37 Scheme of abbreviation: P--love is blind; Q--men are aware of the fact that love is blind; R--women take advantage of the fact that love is blind

Premise 1. $(P \wedge \sim Q) \vee (P \wedge R)$
Premise 2, $\sim Q \rightarrow \sim P$
Conclusion. R

1.	~~Sho~~ R		1.
2.	$\sim R$	AID	2.
3.	$P \wedge \sim Q$	T44, Q/R, 2, MP, Prem 1, MTP	3.
4.	P	3, S	4.
5.	$\sim P$	3, S, Prem 2, MP	5.

#38. Scheme of abbreviation: P--Alfred is a lover of logic; Q--Alfred organizes his time; R--Alfred enjoys Mozart in the morning; S--Alfred enjoys whiskey at night

Premise 1. (P ∧ Q) → (R v S) ∧ ∼(R ∧ S)
Premise 2. S → (R ∧ Q) v (∼R ∧ ∼Q) v ∼P
Premise 3. R ∧ Q → S
Conclusion. P → ∼Q

1.	~~Show~~ P → ∼Q		1.
2.	P	ACD	2.
3.	~~Sho~~ ∼Q		3.
4.	Q	AID	4.
5.	(R v S) ∧ ∼(R ∧ S)	2, 4, Adj, Prem 1, MP	5.
6.	~~Sho~~ S		6.
7.	∼S	AID	7.
8.	∼R v ∼Q	Prem 3, 7, MT, T65, P/R, BC, MP	8.
9.	S	4, DN, 8, MTP, 5, S, MTP	9.
10.	(R ∧ Q) v (∼R ∧ ∼Q)	Prem 2, 6, MP, 2, DN, MTP	10.
11.	~~Sho~~ ∼R		11.
12.	R	AID	12.
13.	∼S	5, S, T65, P/R, Q/S, BC, MP, 12, DN, MTP	13.
14.	S	6, R	14.
15.	∼Q	T43, P/R, 11, MP, 10, MTP, S	15.

#39 Scheme of abbreviation: P--Alfred pays attention; Q--Alfred loses track of the argument; R--Alfred takes notes; S--Alfred does well in the course; T--Alfred studies logic

Premise 1. ∼(P ∧ ∼Q) v∼(∼R ∧ ∼S)
Premise 2. ∼S ∧ ∼Q
Premise 3. T → (∼S → [∼R ∧ P])
Conclusion. ∼T

1.	~~Show~~ ∼T		1.
2.	T	AID	2.
3.	∼R ∧ P	Prem 3, 2, MP, Prem 2, S, MP	3.
4.	∼(P ∧ ∼Q)	Prem 2, S, 3, S, Adj, DN, Prem 1, MTP	4.
5.	P ∧ ∼Q	3, S, Prem 1, S, Adj	5.

Lesson 10. pp. 95-98

#25 Λx(Fx → ∼Gx)
#26 ∼Vx(Fx ∧ ∼Gx)
#27 Vx(Fx ∧ Gx)
#28 VxFx ∧ VxGx
#29 Λx(Fx ∧ Gx → Hx)
#30 Λx(Fx → [Hx → Gx])
#31 Vx(Fx ∧ Gx) ∧ ∼Λx(Gx → Fx)

#33 Λx([Fx v Gx]   Hx → Ix)
#34 Λx(Fx ∧ Gx → Hx v Ix)
#35 Λx(Gx → Fx) ∧ ∼Vx(Hx ∧ Ix) → (VxHx → Vx[∼Gx ∧ ∼Ix])

#37

1-~~Sho~~- ΛxFx ∧ VxGx → Vx(Fx ∧ Gx)

2	ΛxFx ∧ VxGx	ACD
3	VxGx	2, [illegible]
4	Gy	3, EI
5	ΛxFx	2, S
6	Fy	5, UI
7	Fy Gy	6, 4, Adj
8	Vx(Fx ∧ Gx)	7, EG

Ex #38   Th' 205

i v s ⓔ

1.	~~Show~~ ΛxFx ↔ ∼Vx∼Fx		1.
2.	-~~Sho~~- →		2.
3.	ΛxFx	ACD	3.
4.	-~~Sho~~- ∼Vx∼Fx		4.
5.	Vx∼Fx	AID	5.
6.	∼Fx	5, EI	6.
7.	Fx	3, UI	7.
8.	-~~Sho~~- ←		8.
9.	∼Vx∼Fx	ACD	9.
10.	-~~Sho~~- ΛxFx		10.
11.	-~~Sho~~- Fx		11.
12.	∼Fx	AID	12.
13.	Vx∼Fx	12, EG	13.
14.	∼Vx∼Fx	9, R	14.
15.	↔	2, 8, CB	15.

Th: 206

i v s ⓔ

1.	~~-Sho-~~ Show VxFx ↔ ∿Λx∿Fx	
2.	-Sho- →	
3.	VxFx	ACD
4.	-Sho- ∿Λx∿Fx	
5.	Λx∿Fx	AID
6.	Fx	3, EI
7.	∿Fx	5, UI
8.	-Sho- ←	
9.	∿Λx∿Fx	ACD
10.	-Sho- VxFx	
11.	∿VxFx	AID
12.	-Sho- Λx∿Fx	
13.	-Sho- ∿Fx	
14.	Fx	AID
15.	VxFx	14, EG
16.	∿VxFx	11, R
17.	∿Λx∿Fx	9, R
18.	↔	2, 8, CB

Lesson 12. pp. 114-115

#39

1.	~~-Sho-~~ $\Lambda x(Fx \rightarrow Gx \vee Hx) \wedge \sim\Lambda x(Fx \rightarrow Gx) \rightarrow \mathrm{V}x(Fx \wedge Hx)$	
2.	$\Lambda x(Fx \rightarrow Gx \vee Hx) \wedge \sim\Lambda x(Fx \rightarrow Gx)$	ACD
3.1	$\sim\Lambda x(Fx \rightarrow Gx)$	2, S
3.2	$\mathrm{V}x\sim(Fx \rightarrow Gx)$	3.1, QN
3.3	$\sim(Fy \rightarrow Gy)$	3.2, EI
4.1	$\sim(Fy \rightarrow Gy) \rightarrow Fy$	T21, P/Fy, Q/Gy
4.2	Fy	4.1, 3.3, MP
4.3	$\sim(Fy \rightarrow Gy) \rightarrow \sim Gy$	T22, P/Fy, Q/Gy
4.4	$\sim Gy$	4.3, 3.3, MP
4.5	$\Lambda x(Fx \rightarrow Gx \vee Hx)$	2, S
4.6	$Fy \rightarrow Gy \vee Hy$	4.5, UI
4.7	$Gy \vee Hy$	4.6, 4.2, MP
4.8	Hy	4.7, 4.4, MTP
4.9	$Fy \wedge Hy$	4.2, 4.8, Adj
4.10	$\mathrm{V}x(Fx \wedge Hx)$	4.9, EG

#40

1.	~~-Sho-~~ $\sim\mathrm{V}x(Fx \wedge Gx) \leftrightarrow \Lambda x(Fx \rightarrow \sim Gx)$	
2.	~~-Sho-~~ $\rightarrow$	
3.	$\sim\mathrm{V}x(Fx \wedge Gx)$	ACD
4.	~~-Sho-~~ $\Lambda x(Fx \rightarrow \sim Gx)$	
5.	$Fx \rightarrow \sim Gx$	3, QN, UI, T39, P/Fx, Q/Gx, BC, MP
6.	~~-Sho-~~ $\leftarrow$	
7.	$\Lambda x(Fx \rightarrow \sim Gx)$	ACD
8.	~~-Sho-~~ $\sim\mathrm{V}x(Fx \wedge Gx)$	
9.	$\mathrm{V}x(Fx \wedge Gx)$	AID
10.	$Fy \wedge Gy$	9, EI
11.	$\sim(Fy \wedge Gy)$	7, UI, 10, S, MP, 10, S, Adj.
12.	$\leftrightarrow$	2, 6, MP

Ex #41 Th' 208

i v s [✓ e]

1.	~~Show~~ $\Lambda x(Fx \wedge Gx) \leftrightarrow \Lambda xFx \wedge \Lambda xGx$	
2.	~~-Sho-~~ $\rightarrow$	
3.	$\Lambda x(Fx \wedge Gx)$	ACD
4.	~~-Sho-~~ ΛxFx	
5.	Fx	3, UI, S
6.	~~-Sho-~~ ΛxGx	
7.	Gx	3, UI, S
8.	$\Lambda xFx \wedge \Lambda xGx$	4, 6, Adj
9.	~~-Sho-~~ $\leftarrow$	
10.	$\Lambda xFx \wedge \Lambda xGx$	ACD
11.	~~-Sho-~~ $\Lambda x(Fx \wedge Gx)$	
12.	$Fx \wedge Gx$	10, S, UI, 10, S, UI, Adj
13.	$\leftrightarrow$	2, 9, CB

Th' 209

i v s [✓ e]

1.	~~Show~~ $Vx(Fx \wedge Gx) \rightarrow VxFx \wedge VxGx$	
2.	$Vx(Fx \wedge Gx)$	ACD
3.	$Fx \wedge Gx$	2, EI
4.	$VxFx \wedge VxGx$	3, S, EG, 3, S, EG, Adj.

Th' 210

i v s [✓ e]

1.	~~Show~~ $\Lambda xFx \vee \Lambda xGx \rightarrow \Lambda x(Fx \vee Gx)$	
2.	$\Lambda xFx \vee \Lambda xGx$	ACD
3.	~~-Sho-~~ $\Lambda x(Fx \vee Gx)$	
4.	~~-Sho-~~ $\sim Fx \rightarrow Gx$	
5.	$\sim Fx$	ACD
6.	Gx	5, EG, QN, 2, MTP, UI
7.	$Fx \vee Gx$	4, CD

Th' 211

i v [✓ s] e

1.	~~Show~~ (VxFx → VxGx) → Vx(Fx → Gx)		1.
2.	VxFx → VxGx	ACD	2.
3.	~~Sho~~ Vx (Fx → Gx)		3.
4.	∼Vx(Fx → Gx)	AID	4.
5.	Fx ∧ ∼Gx	4, QN, UI, T40, P/Fx, Q/Gx, BC, MP	5.
6.	VxGx	5, S, EG, 2, MP	6.
7.	Gy	6, EI	7.
8.	∼Gy	4, QN, UI, T40, P/Fy, Q/Gy, S	8.

Th' 212

i v [✓ s] e

1.	~~Show~~ (ΛxFx → ΛxGx) → Vx(Fx → Gx)		1.
2.	ΛxFx → ΛxGx	ACD	2.
3.	~~Sho~~ Vx(Fx → Gx)		3.
4.	∼Vx(Fx → Gx)	AID	4.
5.	Fx ∧ ∼Gx	4, QN, UI, T40, P/Fx, Q/Gx, BC, MP	5.
6.	∼ΛxGx	5, S, EG, QN	6.
7.	Vx∼Fx	2, 6, MT, QN	7.
8.	∼Fy	7, EI	8.
9.	Fy	4, QN, UI, T40, P/Fy, Q/Gy, BC, MP, S	9.

Th' 213

i v s [✓ e]

1.	~~Show~~ Λx(Fx↔ Gx) → (ΛxFx ↔ ΛxGx)		1.
2.	Λx(Fx ↔Gx)	ACD	2.
3.	~~Sho~~ ΛxFx → ΛxGx		3.
4.	ΛxFx	ACD	4.
5.	~~Sho~~ ΛxGx		5.
6.	Gx	2, UI, BC, 4, UI, MP	6.
7.	~~Sho~~ ΛxGx → ΛxFx		7.
8.	ΛxGx	ACD	8.
9.	~~Sho~~ ΛxFx		9.
10.	Fx	2, UI, BC, 4, UI, MP	10.
11.	ΛxFx ↔ ΛxGx	3, 7, CB	11.

Th: 214

i v s [✓ e]

1.	~~Show~~ Λx(Fx ↔ Gx) → (VxFx ↔ VxGx)	
2.	Λx(Fx ↔ Gx)	ACD
3.	~~Sho~~ VxFx → VxGx	
4.	VxFx	ACD
5.	Fx	4, EI
6.	VxGx	2, UI, BC, 5, MP, EG
7.	~~Sho~~ VxGx → VxFx	
8.	VxGx	ACD
9.	Gy	8, EI
10.	VxFx	2, UI, BC, 8, MP, EG
11.	VxFx ↔ VxGx	3, 7, CB

Ex #42 Th: 218

i v s [✓ e]

1.	~~Show~~ Vx(P v Fx) ↔ P v VxFx	
2.	~~Sho~~ →	
3.	Vx(P v Fx)	ACD
4.	~~Sho~~ ∿P → VxFx	
5.	∿P	ACD
6.	P v Fx	3, EI
7.	VxFx	6, 5, MTP, EG
8.	P v VxFx	4, CD
9.	~~Sho~~ ←	
10.	P v VxFx	ACD
11.	~~Sho~~ Vx(P v Fx)	
12.	∿Vx(P v Fx)	AID
13.	∿P ∧ ∿Fx	12, QN, UI, T64, Q/Fx, BC, MT, DN
14.	Fy	13, S, 10, MTP, EI
15.	∿Fy	12, QN, UI, T64, Q/Fy, BC, MT, DN, S
16.	↔	2, 9, CB

Th: 219

i v s ⓔ

1.	Show- Λx(P → Fx) ↔ (P → ΛxFx)		1.
2.	-Sho- →		2.
3.	Λx(P → Fx)	ACD	3.
4.	-Sho- P → ΛxFx		4.
5.	P	ACD	5.
6.	-Sho- ΛxFx		6.
7.	Fx	3, UI, 5, MP	7.
8.	-Sho- ←		8.
9.	P → ΛxFx	ACD	9.
10.	-Sho- Λx(P → Fx)		10.
11.	-Sho- P → Fx		11.
12.	P	ACD	12.
13.	Fx	9, 12, MP, UI	13.
14.	↔	2, 8, CB	14.

Th: 221

i v s ⓔ

1.	Show- Λx(Fx → P) ↔ (VxFx → P)		1.
2.	-Sho- →		2.
3.	Λx(Fx → P)	ACD	3.
4.	-Sho- VxFx → P		4.
5.	VxFx	ACD	5.
6.	Fx	5, EI	6.
7.	P	3, UI, 6, MP	7.
8.	-Sho- ←		8.
9.	VxFx → P	ACD	9.
10.	-Sho- Λx(Fx → P)		10.
11.	-Sho- Fx → P		11.
12.	Fx	ACD	12.
13.	P	12, EG, 9, MP	13.
14.	↔	2, 8, CB	14.

Ex #43 Th 223

i v s ⓔ

1.	~~Show~~ $\Lambda x(Fx \leftrightarrow P) \to (\Lambda xFx \leftrightarrow P)$	
2.	$\Lambda x(Fx \leftrightarrow P)$	ACD
3.	~~Sho~~ $\Lambda xFx \to P$	
4.	ΛxFx	ACD
5.	P	2, UI, BC, 4, UI, MP
6.	~~Sho~~ $P \to \Lambda xFx$	
7.	P	ACD
8.	~~Sho~~ ΛxFx	
9.	$\boxed{Fx}$	2, UI, BC, 7, MP
10.	$\Lambda xFx \leftrightarrow P$	3, 6, CB

Th 224

i v s ⓔ

1.	~~Show~~ $\Lambda x(Fx \leftrightarrow P) \to (VxFx \leftrightarrow P)$	
2.	$\Lambda x(Fx \leftrightarrow P)$	ACD
3.	~~Sho~~ $VxFx \to P$	
4.	$VxFx$	ACD
5.	Fx	4, EI
6.	P	2, UI, BC, 5, MP
7.	~~Sho~~ $P \to VxFx$	
8.	P	ACD
9.	$VxFx$	2, UI, BC, 8, MP, EG
10.	$VxFx \leftrightarrow P$	3, 7, CB

Th: 225

i v s [✓ e]

1.	~~Show~~ (VxFx ↔ P) → Vx(Fx ↔ P)		1.
2.	VxFx ↔ P	ACD	2.
3.	~~Sho~~ Vx(Fx ↔ P)		3.
4.	∼Vx(Fx ↔ P)	AID	4.
5.	Fx ↔ ∼P	4, QN, UI, T90, P/Fx, Q/P, BC, MP	5.
6.	~~Sho~~ P		6.
7.	∼P	AID	7.
8.	P	5, BC, 7, MP, EG, 2, BC, MP	8.
9.	Fy	2, BC, 6, MP, EI	9.
10.	∼P	4, QN, UI, T90, P/Fy, Q/P, MP, MP	10.

Ex #44 Th: 240

i v s [✓ e]

C

1.	~~Show~~ Λx(Fx → Gx) ∧ Vx(Fx ∧ Hx) → Vx(Gx ∧ Hx)		1.
2.	Λx(Fx → Gx) ∧ Vx(Fx ∧ Hx)	ACD	2.
3.	Fx ∧ Hx	2, S, EI	3.
4.	Vx(Gx ∧ Hx)	2, S, UI, 3, S, MP, 3, S, Adj, EG	4.

Th: 242

i v s [✓ e]

1.	~~Show~~ ∼Λx(Fx → Gx) ↔ Vx(Fx ∧ ∼Gx)		1.
2.	~~Sho~~ →		2.
3.	∼Λx(Fx → Gx)	ACD	3.
4.	∼(Fx → Gx)	3, QN, EI	4.
5.	Fx ∧ ∼Gx	T40, P/Fx, Q/Gx, BC, 4, MP	5.
6.	Vx(Fx ∧ ∼Gx)	5, EG	6.
7.	~~Sho~~ ←		7.
8.	Vx(Fx ∧ ∼Gx)	ACD	8.
9.	~~Sho~~ ∼Λx(Fx → Gx)		9.
10.	Λx(Fx → Gx)	AID	10.
11.	Fy ∧ ∼Gy	8, EI	11.
12.	Gy	10, UI, 11, S, MP	12.
13.	∼Gy	11, S	13.
14.	↔	2, 7, CB	14.

Th' 245

i v s ⓔ

1.	~~Show~~ ∼VxFx ↔ Λx(Fx → Gx) ∧ Λx(Fx → ∼Gx)	
2.	-Sho- →	
3.	∼VxFx	ACD
4.	-Sho- Λx(Fx → Gx)	
5.	Fx → Gx	3, QN, UI, T18, P/Fx, Q/Gx, MP
6.	-Sho- Λx(Fx → ∼Gx)	
7.	Fx → ∼Gx	3, QN, UI, T18, P/Fx, Q/∼Gx, MP
8.	Λx(Fx → Gx) ∧ Λx(Fx → ∼Gx)	4, 6, Adj
9.	-Sho- ←	
10.	Λx(Fx → Gx) ∧ Λx(Fx → ∼Gx)	ACD
11.	-Sho- ∼VxFx	
12.	VxFx	AID
13.	Fy	12, EI
14.	Gy	10, S, UI, 13, MP
15.	∼Gy	10, S, UI, 13, MP
16.	↔	2, 9, CB

Ex #45 Th' 246

i v s ⓔ

1.	~~Show~~ ΛxFx ↔ ΛxΛy(Fx ∧ Fy)	
2.	-Sho- →	
3.	ΛxFx	ACD
4.	-Sho- ΛxΛy(Fx ∧ Fy)	
5.	Fx ∧ Fy	3, UI, 3, UI, Adj
6.	-Sho- ←	
7.	ΛxΛy(Fx ∧ Fy)	ACD
8.	-Sho- ΛxFx	
9.	Fx	7, UI, UI, X
10.	↔	2, 6, CB

Th' 247

i v s ⓔ

1.	~~Show~~ VxFx ∧ VxGx → (Λx[Fx → Hx] ∧ Λx[Gx → Jx] ↔ ΛxΛy[Fx ∧ Gy → Hx ∧ Jy])	
2.	VxFx ∧ VxGx	ACD
3.	Fz	2, S, EI
4.	Gy	2, S, EI
5.	~~Sho~~ Λx[Fx → Hx] ∧ Λx[Gx → Jx] → ΛxΛy[Fx Gy → Hx ∧ Jy]	
6.	Λx[Fx → Hx] ∧ Λx[Gx → Jx]	ACD
7.	~~Sho~~ ΛxΛy[Fx ∧ Gy → Hx Jy]	
8.	~~Sho~~ Fx ∧ Gy → Hx ∧ Jy	
9.	Fx ∧ Gy	ACD
10.	Hx ∧ Jy	6, S, UI, 9, S, MP, 6, S, UI, 9, S, MP, Adj
11.	~~Sho~~ ΛxΛy[Fx ∧ Gy → Hx ∧ Jy] → Λx[Fx → Hx] ∧ Λx[Gx → Jx]	
12.	ΛxΛy[Fx ∧ Gy → Hx ∧ Jy]	ACD
13.	~~Sho~~Λx[Fx → Hx]	
14.	~~Sho~~ Fx → Hx	
15.	Fx	ACD
16.	Hx	12, UI, UI, 15, 4, Adj, MP, S
17.	~~Sho~~ Λx[Gx → Jx]	
18.	~~Sho~~ Gx → Hx	
19.	Gx	ACD
20.	Jx	12, UI, UI, 19, 3 Adj, MP, S
21.	Λx[Fx → Hx] ∧ Λx[Gx → Jx]	13, 17, Adj
22.	Λx[Fx → Hx] ∧ Λx[Gx → Jx] ↔ ΛxΛy[Fx ∧ Gy → Jx ∧ Jy]	5, 11, CB

Th: 248

i v s ⓔ

1.	~~Show~~ (VxFx ↔ VxGx) ∧ ΛxΛy(Fx ∧ Gy → [Hx ↔ Jy]) → (Λx[Fx → Hx] ↔ Λx[Gx → Jx])		1.
2.	VxFx ↔ VxGx ∧ ΛxΛy(Fx ∧ Gy → [Hx ↔ Jy])	ACD	2.
3.	-Sho- Λx[Fx → Hx] → Λx[Gx → Jx]		3.
4.	Λx[Fx → Jx]	ACD	4.
5.	-Sho- Λx[Gx → Jx]		5.
6.	-Sho- Gx → Jx		6.
7.	Gx	ACD	7.
8.	Fy	2, S, BC, 7, EG, MP, EI	8.
9.	Hy	4, UI, 8, MP	9.
10.	Jx	2, S, UI, UI, 7, 8, Adj, MP, BC, 9, MP	10.
11.	-Sho- Λx[Gx → Jx] → Λx[Fx → Hx]		11.
12.	Λx[Gx → Jx]	ACD	12.
13.	-Sho- Λx[Fx → Hx]		13.
14.	-Sho- Fx → Hx		14.
15.	Fx	ACD	15.
16.	Gz	2, S, BC, 15, EG, MP, EI	16.
17.	Jz	12, UI, 16, MP	17.
18.	Hx	2, S, UI, UI, 15, 16, Adj, MP, BC, 17, MP	18.
19.	Λx[Fx → Hx] ↔ Λx[Gx → Jx]	3, 11, CB	19.
20.			20.
21.			21.
22.			22.
23.			23.
24.			24.
25.			25.
26.			26.
27.			27.
28.			28.
29.			29.
30.			30.
31.			31.
32.			32.

Lesson 13. pp. 117-118

#46

1. ~~Sho~~ $Fx \wedge Gx$
2. $\boxed{Fx \wedge Gx}$ Prem, UI

#47

1. ~~Sho~~ $\Lambda y(Fx \wedge Gy)$
2. $\boxed{Fx \wedge Gx}$ Prem

Ex #48

i v [✓ s] e

1. ~~Show~~ $\Lambda x(Fx \to Jx)$
2. ~~Sho~~ $Fx \to Jx$
3. Fx ACD
4. $\Lambda x(Fx \to \Lambda xGx)$ Prem 1
5. $\Lambda x(Gx \vee Hx) \to \Lambda xJx$ Prem 2
6. $Fx \to \Lambda xGx$ 4, UI
7. ΛxGx 6, 3, MP
8. ~~Sho~~ $\Lambda x(Gx \vee Hx)$
9. ~~Sho~~ $\sim Gx \to Hx$
10. $\sim Gx$ ACD
11. Gx 7, UI
12. $Gx \vee Hx$ 9, CD
13. ΛxJx 5, 8, MP
14. Jx 13, UI

Ex #49

i *v* ⓢ *e*

1.	~~Show~~ Λx(Jx → ∼Ix)	
2.	-Sho- Vx(Hx ∧ ∼Gx)	
3.	∼Vx(Hx ∧ ∼Gx)	AID
4.	Fy ∧ ∼Gy	Prem 1, EI
5.	Hy	Prem 2, UI, 4, S, MP
6.	∼(Hy ∧ ∼Gy)	3, QN, UI
7.	∼Hy v ∼∼Gy	T65, P/Hy, Q/∼Gy, BC, 6, MP
8.	∼Hy	4, S, DN, 7, MTP
9.	-Sho- Jx → ∼Ix	
10.	Jx	ACD
11.	-Sho- ∼Ix	
12.	Ix	AID
13.	Hx	10, 12, Adj, Prem 3, UI, MP, Prem 2, UI, MP
14.	∼Hx	Prem 4, 2, MP, UI, 12, MP

Ex #50

i *v* ⓢ *e*

1.	~~Show~~ Vx(Fx ∧ Hx)	
2.	∼Vx(Fx ∧ Hx)	AID
3.	-Sho- VxFx	
4.	∼VxFx	AID
5.	Gx	Prem 4, 4, MP, EI
6.	∼Ix	Prem 3, QN, UI, T65, P/Ix, Q/Gx, BC, MP, 5, DN, MTP
7.	Ix	Prem 2, UI, 5, Add, MP
8.	Fy	3, EI
9.	∼Hy	2, QN, UI, T39, P/Fx, Q/Hx, 8, DN, MP
10.	Gy v Hy	Prem 1, UI, 8, MP
11.	Iy	Prem 2, UI, 10, MP
12.	∼Iy	Prem 3, QN, UI, T65, P/Iy, Q/Gy, 11, DN, MTP

Ex #51

i v [✓ s] e

1.	~~Show~~ $\bigvee x(Gx \wedge Fx)$	
2.	$\sim \bigvee x(Gx \wedge Fx)$	AID
3.	Fx	Prem 4, EI
4.	~~Sho~~ $\sim \bigwedge x(Fx \rightarrow Gx)$	
5.	$\bigwedge x(Fx \leftrightarrow Gx)$	AID
6.	$Gx \wedge Fx$	5, UI, 3, MP, 3, Adj
7.	$\sim(Gx \wedge Fx)$	2, QN, UI
8.	$Fy \wedge Hy$	Prem 1, 4, MTP, EI
9.	$Iy \wedge Jy$	Prem 3, UI, 8, S, MP
10.	$\sim Jy$	Prem 2, UI, 9, S, MP, 8, S, QN, MTP
11.	Jy	9, S

Ex. 52

1.	~~Sho~~ $\bigwedge x(Fx \wedge Jx \rightarrow Kx)$	
2.	~~Sho~~ $Fx \wedge Jx \rightarrow Kx$	
3.	$Fx \wedge Jx$	ACD
4.	~~Sho~~ $\bigwedge x(Gx \vee Hx)$	
5.	$\boxed{Gx \vee Hx}$	Prem 1, UI, 3, S, MP, UI, Add
6.	$Gy \wedge Iy$	Prem 2, 4, MP, EI
7.	Kx	6, S, EG, Prem 3, MP, UI, 3, S, MP

Ex #53

i v s [✓ e]

1.	~~Show~~ $\bigvee x(Fx \leftrightarrow P)$	
2.	$\sim \bigvee x(Fx \leftrightarrow P)$	AID
3.	~~Sho~~ P	
4.	$\sim P$	AID
5.	$Fx \rightarrow P$	Prem 1, EI
6.	$\sim Fx$	5, 4, MT
7.	Fx	2, QN, UI, T90, P/Fx, Q/P, BC, MP, BC, 4, MP
8.	$P \rightarrow Fy$	Prem 2, EI
9.	Fy	3, 8, MP
10.	$\sim Fy$	2, QN, UI, T90, Q/Fy, BC, MP, BC, 3, MP

#54. For each *x* (*x* is a man and *x* is mortal) .˙. For each *x*, *x* is a man.

F*a*: *a* is a man
G*a*: *a* is mortal

Premise. Λx(Fx Gx)
Conclusion. ΛxFx

```
1. -~~Sho~~-  ΛxFx
2. |Fx|                                          Premise, UI, S
```

#55. There is an object *x* such that *x* is a dog. .˙. There is an object *x* such that (if *x* is a cat, then *x* is a dog).

F*a*: *a* is a dog
G*a*: *a* is a cat

Premise. VxFx
Conclusion. Vx(Gx → Fx)

```
1.-~~Sho~~-  Vx(Gx → Fx)
2.|Fx           |                                Premise, EI
3.|Vx(Gx → Fx)  |                 T2, P/Gx, Q/Fx, 2, MP, EG
```

#56. A gentleman does not prefer blondes only if he is blond.˙. Every gentleman either is blond or prefers blondes.

F*a*: *a* is a gentleman
G*a*: *a* prefers blondes
H*a*: *a* is blonde

Premise. Λx(Fx → [∿Gx → Hx])
Conclusion. Λx(Fx → [Hx v Gx])

```
1. -~~Sho~~-  Λx(Fx → [Hx v Gx])
2.  | -~~Sho~~-  Fx → [Hx v Gx]   |
3.  |  |Fx                    |   |                ACD
4.  |  |   -~~Sho~~-  ∿Hx → Gx    |   |
5.  |  |   |∿Hx|              |   |                ACD
6.  |  |   |Gx |              |   |   Premise, UI, 3, MP, 5, MT, DN
7.  |  |Hx v Gx               |   |                4, CD
```

#57. There is not a single Communist who either likes logic or is able to construct derivations correctly. Some impartial seekers of truth are Communists. Anyone who is not able to construct derivations correctly eschews philosophy. ∴ Some impartial seekers of truth eschew philosophy.

Fa: a is a Communist
Ga: a likes logic
Ha: a is able to construct derivations correctly
Ia: a is an impartial seeker of truth
Ja: a eschews philosophy

Premise 1. $\sim\bigvee x(Fx \wedge [Gx \vee Hx])$
Premise 2, $\bigvee x(Jx \wedge Fx)$
Premise 3. $\bigwedge x(\sim Hx \rightarrow Ix)$
Conclusion. $\bigvee x(Ix \wedge Jx)$

1.	~~Sho~~ $\bigvee x(Ix \wedge Jx)$	
2.	$Ix \wedge Fx$	Premise 2, EI
3.	$\sim Gx \wedge \sim Hx$	Prem 1, QN, UI, T39, P/Fx, Q/Gx ∧ Hx, BC, MP, 2, S, MP, T66, P/Gx, Q/Hx, BC, MP
4.	$\bigvee x(Ix \wedge Jx)$	Prem 3, UI, 3, S, MP. 2, S, Adj, EG

#58. Everyone who signed the loyalty oath is an honest citizen. If someone signed the loyalty oath and was convicted of perjury, or signed the loyalty oath and is a Communist, then not all who signed the loyalty oath are honest citizens. ∴ No one who signed the loyalty oath is a Communist.

Fa: a signed the loyalty oath
Ga: a is an honest citizen
Ha: a was convicted of perjury
Ia: a is a Communist

Premise 1. $\bigwedge x(Fx \rightarrow Gx)$
Premise 2. $\bigvee x([Fx \wedge Hx] \vee [Fx \wedge Ix] \rightarrow \sim\bigwedge x(Fx \rightarrow Gx)$
Conclusion. $\sim\bigvee x(Fx \wedge Ix)$

1.	~~Sho~~ $\sim\bigvee x(Fx \wedge Ix)$	
2.	$\bigvee x(Fx \wedge Ix)$	AID
3.	$Fx \wedge Ix$	2, EI
4.	$\sim([Fx \wedge Hx] \vee [Fx \wedge Ix])$	Prem 1, DN, Prem 2, MT, QN, UI
5.	$\sim[Fx \wedge Ix]$	T66, P/Fx ∧ Hx, Q/Fx ∧ Ix, BC, 4, MP, S

#59. All men who have either a sense of humor or the spirit of adventure seek the company of women. Anyone who seeks the company of women and has the spirit of adventure finds life exciting. Whoever gives in to temptation has the spirit of adventure. ∴ Every man who gives in to temptation finds life exciting.

Fa: *a* is a man
Ga: *a* has a sense of humor
Ha: *a* has the spirit of adventure
Ia: *a* seeks the company of women
Ja: *a* finds life exciting
Ka: *a* gives in to temptation

Premise 1. Λx(Fx ∧ [Gx v Hx] → Ix)
Premise 2. Λx(Ix ∧ Hx → Jx)
Premise 3. Λx(Kx → Hx)
Conclusion. Λx(Fx ∧ Kx → Jx)

1. ~~-Sho-~~ Λx(Fx ∧ Kx → Jx)
2. ~~-Sho-~~ Fx ∧ Kx → Jx
3. Fx ∧ Kx — ACD
4. Hx — Prem 3, UI, 3, S, MP
5. Jx — 4, Add, 2, S, Prem 1, UI, MP, 4, Adj, Prem 2, UI, MP

#60. No egghead is a good security risk. Every professor lives in an ivory tower. If there is someone who lives in an ivory tower and is not a good security risk, then no one who is either a professor or an egghead should be trusted with confidential information. ∴ If some professor is an egghead, then no professor should be trusted with confidential information.

Fa: *a* is an egghead
Ga: *a* is a good security risk
Ha: *a* is a professor
Ia: *a* lives in an ivory tower
Ja: *a* should be trusted with confidential information

Premise 1. ∼Vx(Fx ∧ Gx)
Premise 2. Λx(Hx → Ix)
Premise 3. Vx(Ix ∧ ∼Gx) → ∼Vx([Hx v Fx] ∧ Jx)
Conclusion. Vx(Hx ∧ Fx) → ∼Vx(Hx ∧ Jx)

1. ~~-Sho-~~ Vx(Hx ∧ Fx) → ∼Vx(Hx ∧ Jx)
2. Vx(Hx ∧ Fx) — ACD
3. ~~-Sho-~~ ∼Vx(Hx ∧ Jx)
4. Vx(Hx ∧ Jx) — AID
5. Hx ∧ Jx — 4, EI
6. Ix — Prem 2, UI, 5, S, MP
7. Hy ∧ Fy — 2, EI
8. ∼Gy — Prem 1, QN, UI, T39, P/Fx, Q/Gx, BC, MP, 7, S, MP
9. Vx(Ix ∧ ∼Gx) — Prem 2, UI, 7, S, MP, 8, Adj, EG
10. [Hx v Fx] → ∼Jx — Prem 3, 9, MP, QN, UI, T39, P/Hx v Fx, Q/Jx, BC, MP
11. Jx — 5, S
12. ∼Jx — 5, S, Add, 10, MP

UNIT IV

Lesson 14. pp. 137-138

#11. The circled occurrences of terms are bound.

$(\Lambda y(\mathrm{V}x\ G^2A^0A^1x \vee G^2B^2yz) \rightarrow \Lambda z(G^2B^1yz \vee G^1B^2yz))$

The circled occurrences of terms are free.

$(\Lambda y(\mathrm{V}x\ G^2A^0A^1x \vee G^2B^2yz) \rightarrow \Lambda z(G^2B^1yz \vee G^1B^2yz))$

#12.

Term	*Bound*	*Free*
A^0		✓
A^1x	✓	✓
x	✓	
B^2yz	✓	
y	✓	✓
z	✓	✓
B^1y		✓

#13. F^1A^1x
G^2B^0x
$H^3C^2B^0B^0A^1B^0B^0$
$\Lambda xF^1x \vee P^0 \rightarrow G^2xy \wedge H^3xyz$

Lesson 15. pp. 145-148

#17. $\mathrm{V}x(Fx \wedge \Lambda y[Fy \rightarrow GA(yx)]) \rightarrow \mathrm{V}x(Fx \wedge Gx)$

(i) $\mathrm{V}x(F^1x \wedge \Lambda y(F^1y \rightarrow G^1A^2yx)) \rightarrow \mathrm{V}x(F^1x \wedge G^1x)$
(ii) --same--
(iii) (Vx({a is a number}x ∧ Λy({a is a number}y → {a is even}{the product of a and b}yx)) → Vx({a is a number}x ∧ {a is even}x)
(iv) Vx((x is a number) ∧ Λy((y is a number) → (the product of y and x is even)) → Vx((x is a number) ∧ (x is even))
(v) If there is an x such that (for every y (if y is a number, then the product of y and x is even)) then there is an x such that (x is a number and x is even)

Free translation: If there is a number which, when multiplied with any number produces an even number, there is an even number.

#18. $\Lambda x(Fx \rightarrow \mathrm{V}yG(yx) \wedge \mathrm{V}yH(yx)) \wedge \mathrm{V}x(Fx \wedge \sim[\mathrm{V}yG(xy \vee \mathrm{V}yH(xy)])$

(i) $\Lambda x(F^1x \rightarrow \mathrm{V}yG^2yx \wedge \mathrm{V}yH^2yx) \wedge \mathrm{V}x(F^1x \wedge \sim[\mathrm{V}yG^2xy \vee \mathrm{V}yH^2xy])$
(ii) --same--
(iii) Λx({a is a person}x → (Vy{a is father of b}yx ∧ Vy{a is mother of b}yx) ∧ Vx({a is a person}x ∧ ∿(Vy{a is father of b}xy v Vy{a is mother of b}xy))
(iv) Λx(x is a person → (Vy(y is father of x ∧ Vy y is mother of x) ∧ Vx(x is a person ∧ ∿(Vy x is father of y v Vy x is mother of y)

(v) For every x(if x is a person then (there is a y such that y is father of x and there is a y such that y is mother of x) and (there is an x such that it is not the case that(there is a y such that x is father of y or there is a y such that x is mother of y))

Free translation: Every person has a father and a mother, but there there is a person who is neither father nor mother.

#19. Λx(F(xE) → Vy[G(yE) ∧ H(xy) ∧ I(yB(C(E)))])

(i) $\Lambda x(F^2xE^0 \rightarrow Vy(G^2yE^0 \wedge H^2xy \wedge I^2yB^1C^1E^0))$

(ii) $\Lambda x(F^2x$ the course → Vy(G^2y the course ∧ H^2xy ∧ $I^2yB^1C^1$the course))

(iii) Λx({a is a student of b}x the course → Vy({a is a quiz section of b}y the course ∧ {a attends b}xy ∧ {a is taught by b}y{the teaching assistant of a}{the instructor of a}the course))

(iv) Λx(x is a student of the course → Vy(y is a quiz section of the course ∧ x attends y ∧ y is taught by the teaching assistant of the instructor of the course))

(v) For every x(if x is a student of the course, then there is a y such that (y is a quiz section of the course and x attends y and y is taught by the teaching assistant of the instructor of the course))

Free translation: Every student of the course attends a quiz section, taught by the instructor's teaching assistant.

#21. Λx(Fx v Gx → VyH(yx))*
#22. ∼Vx(Fx ∧ ∼Vy[illegible](yx)) ∧ ∼Λx(Fx → VyG(xy))
#23. Λx(Fx → Vy[Fy ∧ G(yx)])
#24. Vx(Fx ∧ Λy[Fy → G(xy)])

#25. For each x (if x is a teacher, then (if(there is a y such that ((y is a problem and x assigns y) and it is not the case that (there is a z such that(z is a solution of y)))), then it is not the case that x has scruples)

Λx(x is a teacher → ((Vy((y is a problem ∧ x assigns y) ∧ ∼(Vz (z is a solution of y)))) → ∼x has scruples)

Λx({a is a teacher}x → ((Vy(({a is a problem}y ∧ {a assigns b}xy) ∧ ∼(Vz({a is a solution of b}zy)))) → ∼{a has scruples}x))

$\Lambda x(F^1x \rightarrow ((Vy((J^1y \wedge I^2xy) \wedge \sim(Vz(K^2zy)))) \rightarrow \sim G^1x))$

Λx(Fx → ((Vy((Jy ∧ I(xy)) ∧∼(Vz(K(zy))))) → ∼Gx))

Λx(Fx → [Vy(Jy ∧ I(xy) ∧∼VzK(zy)) → ∼Gx])

#26. For each x(x is a particle → the net force acting on x is equal to the product of the mass of x and the acceleration of x)

Λx(x is a particle → the net force acting on x is equal to the product of the mass of x and the acceleration of x)

Λx({a is a particle}x → {a is equal to b}{the net force acting on a}{the product of a and b}{the mass of a}x {the mass of a}x {the acceleration of a} x)

---

*Since the relation 'H' is symmetrical under this scheme of abbreviation, its veribles may occur in either order.

$\Lambda x(F^1x \to G^2A^1xB^2C^1xL^1x)$

$\Lambda x[Fx \to GA(x)B(C(x)D(x))]$

#27. For each x(if x is a princple, then (x is not innate or for each y (if y is a person and y hears x, then y gives his assent to x)))

Λx(x is a principle → (∼x is innate v Λy(yis a person∧y hears x → y gives his assent to x)))

Λx({a is a principle}x → (∼{a is innate}x v Λy({a is a person}y ∧ {a hears b}yx → {a gives his assent to b}yx)))

$\Lambda x(F^1x \to (\sim G^1x \vee \Lambda y(H^1y \wedge I^2yx \to J^2yx)))$

$\Lambda x(Fx \to \sim Gx \vee \Lambda y[Hy \wedge I(yx) \to J(yx)])$

#28. $F^1A^1B^1C^0$

$F(A(B(C)))$

#29. $\Lambda x[Fx \to \sim\Lambda y(Gy \wedge I(xy) \to J(xy)) \vee \Lambda y(Gy \wedge I(xy) \to Hy)]$

#30. For each x (if x is a person and (it is not the case that (There is a y such that (y is a person and x loves x more than x loves y and x is different from y))), then (it is not the case that (there is a y such that (y is a person and y is different from x and y loves x))))

Λx(x is a person ∧ (∼(Vy(y is a person ∧ x loves x more than x loves y ∧ x is different from y))) → (∼(Vy(y is a person ∧ y is different from x ∧ y loves x))))

Λx({a is a person}x ∧ (∼(Vy({a is a person}y ∧ {a loves b more than c loves d}xxxy ∧ {a is different from b}xy))) → (∼(Vy({a is a person}y ∧ {a is different from b}yx ∧ {a loves b}yx))))

$\Lambda x(F^1x \wedge (\sim(Vy(F^1y \wedge L^4xxxy \wedge H^2xy))) \to (\sim(Vy(F^1y \wedge H^2xy \wedge G^2yx))))$

$\Lambda x(Fx \wedge (\sim(VyFy \wedge L(xxxy) \wedge H(xy))) \to (\sim(Vy(Fy \wedge H(yx) \wedge Gyx)))))$

$\Lambda x(Fx \wedge \sim Vy[Fy \wedge L(xxxy) \wedge H(xy)] \to \sim Vy[Fy \wedge H(yx) \wedge G(yx)])$

#31. For each x(if x is a father and (for each y(if y is a child of x, then y is male)), then (it is not the case that there is a y such that (y is a child of x and x has to provide a dowry for y))))

Λx(x is a father ∧ (Λy(y is a child of x → y is male)) → (∼(Vy
(y is a child of x ∧ x has to provide a dowry for y))))

Λx({a is a father}x ∧ (Λy({a is a child of b}yx → {a is male}y))
(∼(Vy({a is a child of b}yx ∧ {a has to provide a dowry for b}xy))))

$\Lambda x(F^1x \wedge (\Lambda y(H^2yx \rightarrow G^1y)) \rightarrow (\sim(Vy(H^2yx \wedge J^2xy))))$

Λx(Fx ∧ (Λy(H(yx) → Gy)) → (∼(Vy(H(yx) ∧ J(xy)))))

Λx(Fx ∧ Λy[H(yx) → Gy] → ∼Vy[H(yx) ∧ J(xy)])

#32. For each x (if x marries the daughter of the brother of the father of x, then the wife of x marries the son of the brother of the husband of the mother of the wife of x)

Λx(x marries the daughter of the brother of the father of x →
the wife of x marries the son of the brother of the husband of the
mother of the wife of x)

Λx({a marries b}x{the daugher of a}{the brother of a}{the father of a}x
→ {a marries b}{the wife of a}x{the son of a}{the brother of a}
{the husband of a}{the mother of a}{the wife of a}x)

$\Lambda x(F^2xB^1C^1D^1x \rightarrow F^2A^1xE^1C^1A^1{}_1B^1{}_1A^1x)$

Λx(F(xB(C(D(x)))) → F(A(x)E(C(A (B (A(x)))))))

#33. If ξ(x is an integer and (x is greater than zero or x is equal to zero)) and for each y(if y is an integer, then y is divisible by x)) then x is equal to 1

((x is an integer ∧ (x is greater than zero v x is equal to zero)) ∧
Λy(y is an integer → y is divisible by x)) → x is equal to 1

$((\{a \text{ is an integer}\}x \wedge (\{a \text{ is greater than } b\}xA^0 \vee \{a \text{ is equal to } b\}xA^0))$
$\wedge\ \Lambda y(\{a \text{ is an integer}\}y \rightarrow \{a \text{ is divisible by } b\}yx)) \rightarrow \{a \text{ is equal to } b\}xB$

$((F^1x \wedge (G^2xA^0 \vee H^2xA^0)) \wedge \Lambda y(F^1y \rightarrow I^2yx)) \rightarrow H^2xB^0$

((Fx ∧ (G(xA) v H(xA))) ∧ Λy(Fy → I(yx))) → H(xB)

Fx ∧ [G(xA) v H(xA)] ∧ Λy[Fy → I(yx)] → H(xB)

Lesson 16, pp. 150-151

#39.

1.	~~-Sho-~~ VxFA(xx)	
2.	ΛxFA(xB)	Prem
3.	FA(BB)	2, UI
4.	VxFA(xx)	3, EG

#40.

1.	~~-Sho-~~ VxFx	
2.	VxFA(xx)	Prem
3.	FA(xx)	2, EI
4.	VxFx	3, EG

#41.

1.	~~-Sho-~~ VxFA[B(x)B(C)x]	
2.	ΛxΛyFA[xB(y)C]	Prem
3.	ΛyFA[B(C)B(y)C]	2, UI
4.	FA[B(C)B(C)C]	3, UI
5.	VxFA[B(x)B(C)x]	4, EG

#42.

1.	~~-Sho-~~ VxFA[B(x)xC]	
2.	ΛxΛyFA[xB(y)C]	Prem
3.	ΛyFA[B(B(y))B(y)C]	2, UI
4.	FA[B(B(y))B(y)C]	3, UI
5.	VxFA[B(x)xC]	4, EG

#43.

1.	~~-Sho-~~ Λx(Vy[H(xy) ∧ Fy] → Vy[H(xy) ∧ Gy])	
2.	~~-Sho-~~ Vy[H(xy) ∧ Fy] → Vy[H(xy) ∧ Gy])	
3.	Vy[H(xy) ∧ Fy]	ACD
4.	H(xy) ∧ Fy	3, EI
5.	Vy[H(xy) ∧ Gy]	4, S, Prem, UI, MP, 4, S, Adj, EG

#44. Λx(Fx → Gx). FA ∴ GA

1.	~~-Sho-~~ GA	
2.	GA	Prem 1, UI, Prem 2, MP

#45. FA(B) ∴ VxFA(x)

1.	~~-Sho-~~ VxFA(x)	
2.	VxFA(x)	Prem, EG

#46. VxFA(x) ∴ VxFx

1.	~~-Sho-~~ VxFx	
2.	FA(x)	Prem, EI
3.	VxFx	2, EG

#47. Fa: a is a number
Ga: a is even
Aab: the product of a and b

$\bigwedge x\bigwedge y(Fx \wedge Fy \rightarrow FA(xy))$
$\bigvee x(Fx \wedge \bigwedge y(Fy \rightarrow GA(xy))$
$\therefore\ \bigvee x(Fx \wedge Gx)$

1.	~~Sho~~ $\bigvee x(Fx \wedge Gx)$	
2.	$\sim\bigvee x(Fx \wedge Gx)$	AID
3.	$Fx \wedge \bigwedge y(Fy \rightarrow GA(xy))$	Prem 2, EI
4.	$GA(xx)$	3, S, UI, 3, S, MP
5.	$\sim FA(xx) \vee \sim GA(xx)$	2, QN, UI, T65, P/FA(xx), Q/GA(xx), BC, MP
6.	$\sim FA(xx)$	4, DN, 5, MTP
7.	$FA(xx)$	Prem 1, UI, UI, 3, S, 3, S, Adj, MP

Lesson 17. P. 155

#48.

T254

1.	~~Sho~~ $\bigvee x\bigvee yF(xy) \leftrightarrow \bigvee x\bigvee y[F(xy) \vee F(yx)]$	
2.	~~Sho~~ $\rightarrow$	
3.	$\bigvee x\bigvee yF(xy)$	ACD
4.	$\bigvee yF(xy)$	3, EI
5.	$F(xy)$	4, EI
6.	$\bigvee x\bigvee y[F(xy \vee F(yx)]$	5, Add, EG, EG
7.	~~Sho~~ $\leftarrow$	
8.	$\bigvee x\bigvee y[F(xy) \vee F(yx)]$	ACD
9.	~~Sho~~ $\bigvee x\bigvee yF(xy)$	
10.	$\sim\bigvee x\bigvee yF(xy)$	AID
11.	$\bigvee y[F(wy) \vee F(yw)]$	8, EI
12.	$F(wz) \vee F(zw)$	11, EI
13.	$\sim[F(wz) \vee F(zw)]$	10, QN, UI, QN, UI, 10, QN, UI, QN, UI, Adj, T66, P/F(wz), Q/F(zw), BC, MP
14.	$\leftrightarrow$	2, 7, CB

T255

1.	~~Sho~~ $\sim\bigvee y\bigwedge x[F(xy) \leftrightarrow \sim F(xx)]$	
2.	$\bigvee y\bigwedge x[F(xy) \leftrightarrow \sim F(xx)]$	AID
3.	$\bigwedge x[F(xy) \leftrightarrow \sim F(xx)]$	2, EI
4.	$\sim(F(yy) \leftrightarrow F(yy))$	3, UI, T90, P/F(yy), Q/F(yy), BC, MP
5.	$F(yy) \leftrightarrow F(yy)$	T91, P/F(yy)

T256

1.	-~~Sho~~- ΛzVyΛx[F(xy) ↔ F(xz) ∧ ∼F(xx)] → ∼VxΛxF(xz)	
2.	ΛzVyΛx[F(xy) ↔ F(xz) ∧ ∼F(xx)]	ACD
3.	-~~Sho~~- ∼VzΛxF(xz)	
4.	VzΛxF(xz)	AID
5.	ΛxF(xz)	4, EI
6.	Λx[F(xy) ↔ F(xz) ∧ ∼F(xx)]	2, UI, EI
7.	F(yy) ↔ F(yz) ∧ ∼F(yy)	6, UI
8.	F(yz)	5, UI
9.	-~~Sho~~- F(yy)	
10.	∼F(yy)	AID
11.	F(yy)	10, 8, Adj, 7, BC, MP
12.	∼F(yy)	7, BC, 9, MP, S

T257

1.	-~~Sho~~- ΛxΛyF(xy) → ΛyΛxF(yx)	
2.	ΛxΛyF(xy)	ACD
3.	-~~Sho~~- ΛyΛxF(yx)	
4.	∼ΛyΛxF(yx)	AID
5.	∼ΛxF(wx)	4, QN, EI
6.	∼F(wz)	5, QN, EI
7.	F(wz)	2, UI, UI

T258

1.	-~~Sho~~- F(xA(x)) ↔ Vy[Λz[F(zy) → F(zA(x))] ∧ F(xy)]	
2.	-~~Sho~~- →	
3.	F(xA(x))	ACD
4.	-~~Sho~~- Vy[Λz[F(zy) → F(zA(x))] ∧ F(xy)	
5.	∼Vy[Λz[F(zy) → F(zA(x))] ∧ F(xy)]	AID
6.	∼Λz[F(zA(x) → F(zA(x)] v ∼F(xA(x))	5, QN, UI, T65, P/Λz[F(zA(x) → F(zA(x)], Q/F(xA(x)), BC, MP
7.	∼[F(zA(x)) → F(zA(x)]	3, DN, 6, MTP, QN, EI
8.	F(zA(x)) → F(zA(x))	T1, P/F(zA(x))
9.	-~~Sho~~- ←	
10.	Vy[Λz[F(zy) → F(zA(x)] ∧ F(xy)]	ACD
11.	Λz[F(zw) → F(zA(x))] ∧ F(zw)[	10, EI
12.	F(xA(x))	11, UI, S, S, MP
13.	↔	2, 9, BC

#49

T260

```
1.  -She-   VxΛy(Fx ↔ Fy) ↔ ∿VxFx v ΛxFx
2.     -She-    →
3.      VxΛy(Fx ↔ Fy)                                   ACD
4.      Λy(Fx ↔ Fy)                                     3, EI
5.          -She-  ∿∿VxFx →  xFx
6.          ∿VxFx                                       ACD
7.             -She-  ΛxFx
8.              Fy                                      6, DN, EI
9.              Fx ↔ Fy                                 4, UI
10.             Fx                                      9, BC, 8, MP

11.      VxFx v  xFx                                    5, CD

12.    -She- ←
13.     ∿VxFx v ΛxFx                                    ACD
14.        -She-  VxΛy(Fx ↔ Fy)
15.         ∿VxΛy(Fx ↔ Fy)                              AID
16.         ∿(Fx ↔ Fz)                                  15, QN, UI, QN, EI
17.           -She-  ∿VxFx → (Fx ↔ Fx)
18.            ∿VxFx                                    ACD
19.            ∿Fx ∧ ∿Fz                                18, QN, UI, 18, QN, UI, Adj.
20.            Fx ↔ Fz                                  T85, P/Fx,  Q/Fz, 19, MP

21.           -She-  ΛxFx → (Fx ↔ Fz)
22.            ΛxFx                                     ACD
23.            Fx ↔ Fz                                  22, QN, UI, QN, UI,
                                                           Adj, T84, P/Fx,
                                                           Q/Fz,MP

24.            Fx ↔ Fz                                  13, 17, 21, SC

25.   ↔                                                 2, 11, CB
```

T261

```
 1. -Sho-  Λx(Fx → Vy[Gy ∧ (Hy v Hx)]) ↔
        Vx(Gx ∧ Hx) v ∿VxFx v (VxGx ∧ Λx[Fx → Hx])
 2. -Sho-  →
 3.  Λx(Fx → Vy[Gy ∧ (Hy v Hx]))                      ACD
 4.     -Sho-  ∿Vx(Gx ∧ Hx) →
                [∿VxFx v (VxGx ∧ Λx[Fx → Hx])]
 5.     ∿Vx(Gx ∧ Hx)                                  ACD
 6.        -Sho-  ∿∿VxFx → (VxGx ∧ Λx[Fx → Hx])
 7.        ∿∿VxFx                                     ACD
 8.        Fx                                         7, DN, EI
 9.        Gy ∧ (Hy v Hx)                             3, UI, 8, MP, EI
10.           -Sho-  Λx[Fx → Hx]
11.           Fx → Hx                                 5, QN, UI, T65, P/Gy,
                                                      Q/Hy, BC, MP, 9, S,
                                                      DN, MTP, 9, S, MTP,
                                                      T2, P/Fx, Q/Hx, MP
12.        VxGx ∧ Λx[Fx → Hx]                         9, S, EG, 10, Adj
13.      ∿VxFx v (VxGx ∧ Λx[Fx → Hx])                 6, CD
14.     Vx(Gx ∧ Hx) v ∿VxFx v (VxGx ∧ Λx[Fx → Hx])    4, CD

15. -Sho-  ←
16.  Vx(Gx ∧ Hx) v ∿VxFx v (VxGx ∧ Λx[Fx → Hx]       ACD
17.  (VxGx ∧ Λx[Fx → Hx]) v Vx(Gx ∧ Hx) v ∿VxFx       T53, P/Vx Gx∧
                                                      Λx[Fx → Hx], Q/
                                                      Vx(Gx ∧ Hx) v ∿VxFx, BC,
                                                      16, MP
18.    -Sho-  Λx(Fx → Vy[Gy ∧ (Hy v Hx)])
19.           -Sho-  Fx → Vy[Gy ∧ (Hy v Hx)]
20.           Fx                                      ACD
21.           VxGx ∧ Λx[Fx → Hx] v Vx(Gx ∧ Hx)        20, EG, DN, 17, MTP
22.              -Sho- VxGx ∧ Λx[Fx → Hx] →
                        Vy[Gy ∧ (Hy v Hx)]
23.              VxGx ∧ Λx[Fx → Hx]                   ACD
24.              Gz                                   23, S, EI
25.              Hz v Hx                              23, S UI, 20, MP, Add
26.              Vy[Gy ∧ (Hy v Hx)]                   24, 25, Adj, EG
27.              -Sho-  Vx(Gx ∧ Hx) →
                         Vy[Gy ∧ (Hy v Hx)]
28.              Vx(Gx ∧ Hx)                          ACD
29.              Gw ∧ Hw                              28, EI
30.              Vy[Gy ∧ (Hy v Hx)]                   29, S Add, 29, S,
                                                      Adj, EG
31.           Vy[Gy ∧ (Hy v Hx)]                      21, 22, 27, SC

32.  ↔                                                2, 15, CB
```

Ex #50 Th 264

i v s [✓ e]

1.	~~Show~~ $(\bigvee x Fx \rightarrow [\bigvee x Gx \rightarrow \bigwedge x Hx]) \leftrightarrow \bigwedge x \bigwedge y \bigwedge z (Fx \wedge Gy \rightarrow Hz)$	
2.	~~Show~~ $\rightarrow$	
3.	$\bigvee x Fx \rightarrow [\bigvee x Gx \rightarrow \bigwedge x Hx]$	ACD
4.	~~Show~~ $\bigwedge x \bigwedge y \bigwedge z (Fx \wedge Gy \rightarrow Hz)$	
5.	~~Show~~ $Fx \wedge Gy \rightarrow Hz$	
6.	$Fx \wedge Gy$	ACD
7.	Hz	6, S, EG, 3, MP, 6, S, EG, MP, UI
8.	~~Show~~ $\leftarrow$	
9.	$\bigwedge x \bigwedge y \bigwedge z (Fx \wedge Gy \rightarrow Hz)$	ACD
10.	~~Show~~ $\bigvee x Fx \rightarrow [\bigvee x Gx \rightarrow \bigwedge x Hx]$	
11.	$\bigvee x Fx$	ACD
12.	~~Show~~ $\bigvee x Gx \rightarrow \bigwedge x Hx$	
13.	$\bigvee x Gx$	ACD
14.	~~Show~~ $\bigwedge x Hx$	
15.	Fw_1	11, EI
16.	Gw_2	13, EI
17.	Hx	9, UI, UI, UI, 15, 16, Adj, MP
18.	$\leftrightarrow$	2, 8, CB

1 ~~44~~

Ex: #51 Th: 269

i v s ⓔ

1.	~~Show~~ VyΛx(Fx v Gy) ↔ ΛxVy(Fx v Gy)	
2.	~~Show~~ →	
3.	VyΛx(Fx v Gy)	ACD
4.	~~Show~~ ΛxVy(Fx v Gy)	
5.	Λx(Fx v Gy)	3, EI
6.	Vy(Fx v Gy)	5, UI, EG
7.	~~Show~~ ←	
8.	ΛxVy(Fx v Gy)	ACD
9.	~~Show~~ VyΛx(Fx v Gy)	
10.	~VyΛx(Fx v Gy)	AID
11.	~(Fx v Gw_1)	10, QN, UI, QN, EI
12.	~Fx ∧ ~Gw_1	T67, P/Fx, Q/Gw_1, BC, 11, MP
13.	Fx v Gw_2	8, UI, EI
14.	Gw_2	12, S, 13, MTP
15.	~~Show~~ Λx(Fx v Gw_2)	
16.	Fx v Gw_2	14, Add
17.	VyΛx(Fx v Gy)	15, EG
18.	↔	2, 7, CB

Lesson 19. pp. 161-164

#53. F(xy) → VzF(zy)

(i) Solved in text
(ii) Solved in text
(iii) I:{G(baa)}xy → Vz{G(baa)}zy
II: G(yxx) → VzG(yzz)
(iv) I:{VwG(awb)}xy → Vz{VwG(awb)}zy
II: VxG(xwy) → VzVwG(zwy)
(v) No; clash of variables.
(vi) I:{VwGw}xy → Vz{VwGw}zy
II:VwGw → VzVwGw
(vii) I:{G(abc)}xy → Vz{G(abc)}zy
II:G(xyc) → VzG(zyc)
(viii) I:{G(bw}xy → Vz{G(bw)}zy
II:G(yw) → VzG(yw)
(ix) No; clash of variables.
(x) I:{G(a)}xy → Vz{G(a)}zy
II:G(x) → VzG(z)

#54. Fx → VyFy

(i) Solved in text
(ii) Solved in text
(iii) G(aa)
I: {G(aa)}x → Vy{G(aa)}y
II: G(xx) → VyG(yy)
(iv) No; clash of variables
(v) No; clash of variables
(vi) ΛwG(wa)
I: {ΛwG(wa)}x → Vy{ΛwG(wa)}y
II: ΛwG(wx) → Vy{wG(wy)}
(vii) No possible substituend
(viii) ΛwG(ww)
I: {ΛwG(ww)}x → Vy{ΛwG(ww)}y
II: ΛwG(ww) → VyΛwG(ww)
(ix) No possible substituend
(x) P
I: {P}x → Vy{P}y
II: P → VyP

#55. ΛxFA(xz) → VyFA(yz)

(i) I: ΛxF{B(C(b)a)}xz → VyF{B(C(b)a)}yz
II: ΛxFB(C(z)x) → VyFB(C(z)y)
(ii) No; clash of variables
(iii) I: ΛxF{B(a)}xz → VyF{B(a)}yz
II: ΛxFB(x) → VyFB(y)
(iv) I: ΛxF{B(b)}xz → VyF{B(b)}yz
II: ΛxFB(z) → VyFB(z)

(v) I: $\Lambda xF\{B\}xz \rightarrow VyF\{B\}yz$
II: $\Lambda xFB \rightarrow VyFB$
(vi) I: $\Lambda xF\{B(acb)\}xz \rightarrow VyF\{B(acb)\}yz$
II: $\Lambda xFB(xcz) \rightarrow VyFB(ycz)$
(vii) I: $\Lambda xF\{B(C(a))\}xz \rightarrow VyF\{B(C(a))\}yz$
II: $\Lambda xFB(C(x)) \rightarrow VyFB(C(y))$
(viii) No.
(ix) No.
(x) I: $\Lambda xF\{B(A(bw)C(a))\}xz \rightarrow VyF\{B(A(bw)C(a))\}yz$
II: $\Lambda xFB(A(zw)C(x) \rightarrow VyFB(A(zx)C(y))$

#56. $F(A(zy)y) \rightarrow VxF(A(xy)y)$

(i) $B[C(b)]$
I: $F(\{B[C(a)]\}zy\ y) \rightarrow VxF(\{B(C(a)]xy\}y)$
II: $F(B[(z)]y) \rightarrow VxF[B(C(x)]y)$

(ii) No.

(iii) $A(ba)$
I: $F(\{A(ba)\}zy\ y) \rightarrow VxF(\{A(ba)\}xy\ y)$
II: $F(A(yz)y) \rightarrow VxF(A(yx)y)$

(iv) No.

(v) No.

#57.

(i) Solved in text.

(ii) Solved in text.

(iii) $\Lambda x(Fx \rightarrow \{\Lambda xG(yz)\}) \leftrightarrow (VxFx \rightarrow \{\Lambda xG(yz)\})$
$\Lambda x(Fx \rightarrow \Lambda zG(yz)) \leftrightarrow (VxFx \rightarrow \Lambda zG(yz))$
$\Lambda x(\{F(aw)\}x \rightarrow \Lambda zG(yz)) \leftrightarrow (Vx\{F(aw)\}x \rightarrow \Lambda zG(yz))$
$\Lambda x(F(xw) \rightarrow \Lambda zG(yz)) \leftrightarrow (VxF(xw) \rightarrow \Lambda zG(yz))$
$\Lambda x(F(xy) \rightarrow \Lambda zG(yz)) \leftrightarrow (VxF(xy) \rightarrow \Lambda zG(yz))$

(iv) $\sim VxFx \rightarrow \Lambda x(Fx \rightarrow Gx)$
$\sim Vx\{VyF(ay)\}x \rightarrow \Lambda x(\{VyF(ay)\}x \rightarrow Gx)$
$\sim VxVyF(xy) \rightarrow \Lambda x(VyF(xy) \rightarrow Gx)$
$\sim VxVyF(xy) \rightarrow \Lambda x(VyF(xy) \rightarrow \{\Lambda zG(A(a)zB(a))\}x)$
$\sim VxVyF(xy) \rightarrow \Lambda x(V_yF(xy) \rightarrow \Lambda zG(A(x)zB(x)))$

(v) No.

(vi) Fy → VxFx

{F(za)}y → Vx{F(za)}x

F(zy) → VxF(zx)

F(xy) → VxF(xx)

#58.

1. ~~-Sho-~~ Λy[Fy → GA(y)] → ΛyΛz[Fz → GA(z)]
2. | Λy[Fy → GA(y) ACD
3. | -~~Sho~~ΛyΛz[Fz → GA(z)
4. | |Fz → GA(z)| 2, UI

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#59. Solved in text

#60. T230

1.	-Sho- $\bigvee x(Fx \to \bigwedge xFx)$	
2.	$\sim\bigvee x(Fx \to \bigwedge xFx)$	AID
3.	$\sim(\bigwedge xFx \to \bigwedge xFx)$	2. T222, $P/\bigwedge xFx$, IE
4.	$\bigwedge xFx \to \bigwedge xFx$	T1, P/ xFx

#61. T265

1.	-Sho- $\bigwedge x(\bigvee y[H(xy) \wedge Fy] \to \bigvee y[H(xy) \wedge Gy]) \leftrightarrow$ $\bigwedge x\bigwedge y\bigvee z(H(xy) \wedge Fy \to H(xz) \wedge Gz)$	
2.	$\bigwedge x(\bigvee y[H(xy) \wedge Fy] \to \bigvee y[H(xy) \wedge Gy])$ $\leftrightarrow \bigwedge x(\bigvee y[H(xy) \wedge Fy] \to \bigvee y[H(xy) \wedge Gy])$	T91
3.	$\leftrightarrow \bigwedge x(\bigvee y[H(xy) \wedge Fy] \to \bigvee z[H(xz) \wedge Gz])$	2, AV
4.	$\leftrightarrow \bigwedge x\bigwedge y(H(xy) \wedge Fy \to \bigvee z[H(xz) \wedge Gz])$	3, T222, AV, x/w, $F/H(xw) \wedge Fw$ $P/\bigvee z[H(xz) \wedge Gz]$, IE,
5.	$\leftrightarrow \bigwedge x\bigwedge y\bigvee z(H(xy) \wedge Fy \to H(xz) \wedge Gz)$	4, T220, AV, x/z, $P/H(xy) \wedge Fy$, $F/[H(xa) \wedge Ga]$, IE

#62. T266

1.	-Sho- $\bigwedge x(Fx \wedge \bigvee yG(xy) \to \bigvee y[H(xy) \wedge \bigwedge zJ(xyz)]) \leftrightarrow$ $\bigwedge x\bigwedge y\bigvee w\bigwedge z[Fx \wedge G(xy) \to H(xw) \wedge J(xwz)]$	
2.	$\bigwedge x(Fx \wedge \bigvee yG(xy) \to \bigvee y[H(xy) \wedge \bigwedge zJ(xyz)])$ $\leftrightarrow \bigwedge x(Fx \wedge \bigvee yG(xy) \to \bigvee w[H(xw) \wedge \bigwedge zJ(xyz)])$	T91, AV
3.	$\leftrightarrow \bigwedge x\bigwedge y(Fx \wedge G(xy) \to \bigvee w\bigwedge z[H(xw) \wedge J(xwz)])$	2, T216, AV, IE
4.	$\leftrightarrow \bigwedge x\bigwedge y\bigvee w\bigwedge z(Fx \wedge G(xy) \to H(xw) \wedge J(xwz))$	3, T220, IE, T219, IE

#63. T268

1.	-Sho- $\bigvee y\bigwedge x(Fx \to Gy) \to \bigwedge x\bigvee y(Fx \to Gy)$	
2.	$\bigvee y\bigwedge x(Fx \to Gy)$	ACD
3.	$\bigwedge x\bigvee y(Fx \to Gy)$	T221, IE, T220, AV, y/w, IE, T221,IE, T220, AV, IE

#64. T271

1.	-~~Sho~~- $\Lambda x\Lambda y\mathrm{V}z(Fx \wedge Gy \rightarrow Hz)$ $\leftrightarrow \Lambda y\mathrm{V}z\Lambda x(Fx \wedge Gy \rightarrow Hz)$	
2.	$\Lambda x\Lambda y\mathrm{V}z(Fx \wedge Gy \rightarrow Hz)$ $\leftrightarrow \Lambda x\Lambda y(Fx \wedge Gy \rightarrow \mathrm{V}zHz)$	T91, T220, AV, IE
3.	$\leftrightarrow \Lambda x(Fx \wedge \mathrm{V}yGy \rightarrow \mathrm{V}zHz)$	2, T221, AV, IE, T216, AV, IE
4.	$\leftrightarrow (\mathrm{V}yGy \wedge \mathrm{V}xFx \rightarrow \mathrm{V}zHz)$	3, T221, IE, T24, IE, T216, IE
5.	$\leftrightarrow \Lambda y\mathrm{V}z(Gy \wedge \mathrm{V}xFx \rightarrow Hz)$	4, T221, AV, IE, T220, AV, IE
6.	$\leftrightarrow \Lambda y\mathrm{V}z\Lambda x(Fx \wedge Gy \rightarrow Hz)$	5, T216, IE, T221, IE, T24, IE

#65. Solved in text.

#66. Scheme of abbreviation--F^2: a is an inhabitant of b; G^2: a shaves b; A^0: Berkeley; B^0: Alfred

Premise 1: $\Lambda x(F(xA) \rightarrow [S(Bx) \leftrightarrow \sim S(xx)])$
Premise 2: $F(BA)$
Conclusion: $S(BB)$

1.	-~~Sho~~- $S(BB)$	
2.	$\sim S(BB)$	AID
3.	$S(BB)$	Prem 1, UI, Prem 2, MP, BC, 2, MP

#67. Scheme of abbreviation--F^1: a is a student; G^1: a is a problem; H^2: a is able to solve b; I^1: a is a teacher

Premise 1: $\Lambda x(Fx \rightarrow \mathrm{V}y(Gy \wedge H(xy))) \wedge \mathrm{V}y(Gy \wedge \sim H(xy))$
Premise 2: $\mathrm{V}x(Ix \wedge \Lambda y[Gy \rightarrow H(xy)])$
Conclusion: $\mathrm{V}x(Ix \wedge \sim Fx)$

1.	-~~Sho~~- $\mathrm{V}x(Ix \wedge \sim Fx)$	
2.	$\sim \mathrm{V}x(Ix \wedge \sim Fx)$	AID
3.	$Ix \wedge \Lambda y[Gy \rightarrow H(xy)]$	Prem 2, EI
4.	$Ix \wedge \sim\sim Fx$	2, QN, T40, IE, UI
5.	$\mathrm{V}y(Gx \wedge H(xy)) \wedge \mathrm{V}y(Gy \wedge \sim H(xy))$	Prem 1, UI, 4, S, DN, MP
6.	$Gy \wedge \sim H(xy)$	5, S, EI
7.	$H(xy)$	3, S, UI, 6, S, MP
8.	$\sim H(xy)$	6, S

#68. Scheme of abbreviation--F^1: a is a member of the Board of Regents; G^2: a distrusts b; H^1: a is a member of the Communist Party; I^1: a is a proponent of Marxism; J^1: a is on the faculty.

Premise 1: $\Lambda x(Fx \rightarrow \Lambda y[Hy \rightarrow \sim G(xy)])$
Premise 2: $\Lambda x(Ix \rightarrow Hx)$
Premise 3: $Vx(Fx \wedge Vy[Iy \wedge \sim G(xy)])$
Conclusion: $Vx(Hx \wedge Jx)$

1.	~~Sho~~ $Vx(Hx \wedge Jx)$	
2.	$Fx \wedge Vy[Iy \wedge \sim G(xy)]$	Prem 3, EI
3.	$Iy \wedge \sim G(xy)$	2, S, EI
4.	$G(xy)$	Prem 2, UI, 3, S, MP, Prem 1, UI, 2, S, MP, UI, MP
5.	$\sim G(xy)$	

#69. Scheme of abbreviation--F^1: a is a student; G^2: a likes b; H^1: a is a course; I^2: a takes b; J^1: a is a philosophical study; K^1: a is a mathematical study.

Premise 1: $\Lambda x \Lambda y(Fx \wedge Hy \wedge I(xy) \rightarrow \sim G(xy) \vee \sim Vz[Hz \wedge I(xz) \wedge \sim Jz])$
Premise 2: $\sim Vx(Kx \wedge Jx)$
Premise 3: $Vx(Fx \wedge \sim Vy[I(xy) \wedge \sim Ky] \wedge \Lambda y[Hy \wedge I(xy) \rightarrow \sim G(xy)])$
Conclusion: $Vx(Fx \wedge \sim Vy[I(xy) \wedge Hy])$

1.	~~Sho~~ $Vx(Fx \wedge \sim Vy[I(xy) \wedge Hy])$	
2.	$\sim Vy(Fx \wedge \sim Vy[I(xy) \wedge Hy])$	AID
3.	$Fx \wedge \sim Vy[I(xy) \wedge \sim Ky] \wedge \Lambda y[Hy \wedge I(xy) \rightarrow G(xy)]$	Prem 3, EI
4.	$I(xy) \wedge Hy$	2, QN, UI, T40, IE, DN, 3, S, MP, EI
5.	$\sim G(xy) \vee \sim Vz[Hx \wedge I(xy) \wedge \sim Jz]$	Prem 1, UI, UI, T24, 4, IE, 3, S. Adj, MP
6.	$\sim [Hy \wedge I(xy) \wedge \sim Jz]$	3, S, UI, T24, IE, 4, MP
7.	$\sim I(xy) \vee \sim\sim Ky$	3, S, S, QN, UI, T65, IE
8.	$\sim\sim Ky$	4, S, DN, 7, MTP
9.	$\sim\sim Jz$	Prem 2, QN, UI, T65, 8, MTP
10.	$\sim(I(xy) \wedge Hy)$	6, T65, IE, 9, MTP

#70. Scheme of abbreviation--F^2: a is a member of b; G^3: a owes b to c; H^1: a is a debt; I^2: a has paid b; A^0: the club; B^1: the treasurer of a; C^0: the entrance fee.

Premise 1: $\sim\bigvee x(FxA) \wedge \bigvee y(Hy \wedge G(xyB(A))))$
Premise 2: $\bigwedge x(FxA) \wedge \sim I(xC) \rightarrow \bigvee y(Hy \wedge G(xyB(A))))$
Conclusion: $F(B(A)A) \rightarrow I(B(A)C)$

1.	-~~Sho~~- $F(B(A)A) \rightarrow I(B(A)C)$	
2.	$F(B(A)A)$	ACD
3.	-~~Sho~~- $I(B(A)C)$	
4.	$\sim I(B(A)C)$	
5.	$F(BA) \wedge \sim I(B(A)C) \rightarrow \bigvee y(Hy \wedge G(B(A)yB(A)))$	Prem 2, UI
6.	$F(BA) \rightarrow \sim\bigvee y(Hy \wedge G(B(A)yB(A)))$	Prem 1, UI, T39, IE
7.	$\bigvee y(Hy \wedge G(B(A)yB(A)))$	2, 4, Adj, 5, MP
8.	$\sim\bigvee y(Hy \wedge G(B(A)yB(A)))$	6, 2, MP

Staple

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Polecat Logic Derivation Sheet

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Polecat Logic Derivation Sheet

Staple

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Polecat Logic Derivation Sheet

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Polecat Logic Derivation Sheet

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